KENTRIODON PERNIX, A MIOCENE PORPOISE FROM MARYLAND

By Remington Kellogg

Of the Bureau of Biological Survey, United States Department of Agriculture

After having recently reexamined the types of the fossil porpoises described from the Miocene formations of Maryland and Virginia, the problem of allocating some of these species arose and this in turn led to a reconsideration of several undescribed specimens in the National Museum. Among Cope's types are two porpoises, *Delphinapterus ruschenbergeri*[1] *and Priscodelphinus stenus*,[2] with vertebrae of approximately the same size as those of the porpoise described in this paper. After some study it was decided that, on the basis of vertebral characters, one of these porpoises may be related or referable to the genus *Delphinodon* and that the other appears to have more features in common with the living genus *Stenodelphis* than with any other porpoise. The vertebrae of these two porpoises have some very distinctive features and it was deemed advisable to discuss them more fully in this connection and to point out the essential peculiarities which seem to distinguish them from those of the porpoise hereinafter described.

DELPHINAPTERUS RUSCHENBERGERI Cope

The fossil porpoise *Delphinapterus ruschenbergeri* was based upon a lumbar and a caudal vertebra (Cat. No. 11233, Academy of Natural Sciences of Philadelphia); they may have belonged to a porpoise in the same genus as *Delphinodon dividum*, but this is uncertain. On both of these small vertebrae the basal portions of the comparatively long transverse processes are preserved. The anterior and posterior margins of the right transverse process of the type lumbar are eroded and one can not be certain whether the transverse processes were like those of *Kentriodon* which have expanded extremities or like the attenuate type exemplified by *Delphinodon dividum*. The centra of these vertebrae are long—not short and

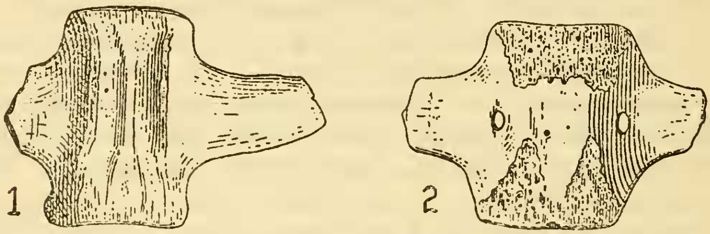
[1] Cope, E. D., Second contribution to the history of the Vertebrata of the Miocene period of the United States. Proc. Acad. Nat. Sci. Philadelphia, vol. 20, p. 189. July, 1868.

[2] Cope, E. D., Idem., p. 188.

No. 2645.—Proceedings U. S. National Museum, Vol. 69, Art. 19.

deep as in corresponding vertebrae of *Stenodelphis* and other living porpoises. There is also a longitudinal carina on the concave floor of the neural canal, like on the lumbars of *Delphinodon dividum.* That this lumbar is an anterior one is shown by the width of the neural canal and the anteroposterior diameter of the neural arch at the base.

If any reliance can be placed upon the proportions of the transverse processes, then the caudal also is an anterior one. No importance is attached to the perforation of the transverse process at the base, because in the caudal vertebrae of *Phocaena phocoena* the foramen is very variable in its appearance. Skeletons were examined in which the second caudal was the first with the transverse processes perforated at the base; on others it was the third, fourth, or



FIGS. 1–2.—1, DORSAL VIEW OF TYPE LUMBAR OF DELPHINAPTERUS RUSCHENBERGERI COPE. 2, VENTRAL VIEW OF TYPE CAUDAL OF DELPHINAPTERUS RUSCHENBERGERI COPE × ⅔. (AFTER CASE)

even the fifth, and in one instance it was the seventh. In case of another porpoise, *Neomeris phocaenoides*, the eighth caudal was the first with the transverse processes perforated at the base. On the fossil caudal there is a depression above the transverse process, but not below. The inferior surface of the centrum is eroded at both ends, which accounts for the absence of the facets for the chevron bones. The transverse processes are relatively very narrow.

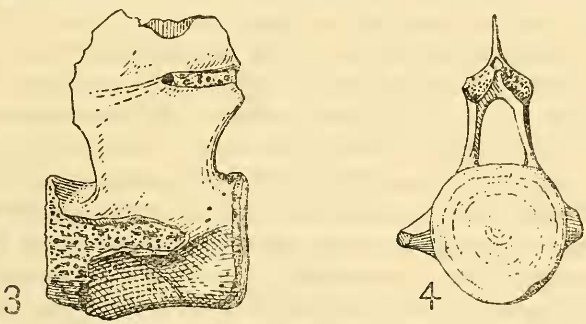
For their position in the series, both vertebrae are very long as compared with any of the living Delphinidae and are in that respect most like those of *Kentriodon.* In other respects, as has been pointed out in the foregoing remarks, these two vertebrae are so unlike those of *Kentriodon* that the writer has no hesitancy in stating that they belong to a quite different type of porpoise.

Measurements of the type vertebrae (in millimeters)

	Lumbar	Caudal
Length of centrum	45	41
Breadth of anterior face of centrum	26	31
Height of anterior face of centrum	22	27
Anteroposterior diameter of base of transverse process	25	26
Length of base of neural arch	28	29 (?)
Breadth of neural canal	11	4
Distance between perforations at base of transverse processes	—	23

PRISCODELPHINUS STENUS Cope

Cope says that he had two lumbar vertebrae of the fossil porpoise *Priscodelphinus stenus*, but only one (Cat. No. 11240, Academy of Natural Sciences of Philadelphia) was found and this vertebra was figured by Case.[3] This is a small vertebra with a very thin anterior epiphysis, broad neurapophysis, and a thin-edged inferior longitudinal carina; the posterior epiphysis is missing. In general appearance this vertebra resembles the third or fourth lumbars of *Stenodelphis.* It is characterized by the unusual proportions of the base of the neural spine, the anteroposterior diameter being proportionately greater than on the corresponding vertebra of any porpoise of the same size known to the writer. The nearest approach to this type of neural spine is found in the lumbars of *Stenodelphis*, a living porpoise of approximately the same size. When complete the neural spine was several millimeters broader anteroposteriorly at the base, for the thick posterior border has suffered from erosion or breakage. The posterior face of the centrum is flat, with a large central pit and about 14 ridges radiating from it. The anterior epiphysis is depressed centrally. The posterior end of the centrum is lower than the anterior, a modification also present in the lumbars of *Kentriodon.* Superiorly the sides of the centrum are flat and inferiorly they are concave, a condition which is traceable to the presence of a narrow diagonal groove on each side of the longitudinal inferior carina. Each of these diagonal grooves terminates mesially anterior to the middle of the centrum and extends backward and upward to the posterior margin of the basal portion of the transverse process. The remnants of the metapophyses indicate that they were more prominent than in *Stenodelphis.* Although the transverse processes are broken off at the base, they agree with those



FIGS. 3–4.—3, LATERAL VIEW (RIGHT SIDE) OF TYPE LUMBAR OF PRISCODELPHINUS STENUS COPE. × ⅔. 4, ANTERIOR VIEW OF TYPE LUMBAR OF PRISCODELPHINUS STENUS COPE. × ⅔. (AFTER CASE)

[3] Case, E. C., Miocene Atlas, Maryland Geological Survey, Baltimore, pl. 13, figs. 1*a*, 1*b*, 1904.

of *Stenodelphis* in their anteroposterior diameter. So far as the present evidence goes, there are adequate reasons for considering that the peculiarities of the type lumbar of *Priscodelphinus stenus* indicates the presence of a porpoise in the Maryland deposits whose skeleton will be found to possess vertebrae of a type not unlike those of *Stenodelphis*.

Measurements of the type vertebra (in millimeters)

Length of centrum	39.4
Breadth of centrum	26
Height of centrum	26
Minimum anteroposterior diameter of neurapophysis	25
Breadth of neural canal	11.6
Distance between superior margin of metapophysis at base and top of centrum	16.4

Four other species, *atropius*, *conradi*, *harlani*, and *spinosus* are referred to *Priscodelphinus* in the article in which *stenus* is described. Cope subsequently withdrew four of these five species from the genus *Priscodelphinus*. In 1875, Cope[4] referred *Priscodelphinus stenus* to his genus *Belosphys*. Fifteen years later when Cope[5] published a list of the extinct Cetacea of North America, he again changed the generic position of this species and referred it to *Ixacanthus*. The species *stenus* has remained in the genus *Ixacanthus* since that time.

To summarize briefly the evidence in favor of the assumption that this porpoise represents an undescribed form, it might be pointed out that the transverse processes of the type caudal of *Delphinapterus ruschenbergeri* are too slender to indicate any close relationship and that the anteroposterior diameters of the neural spine, neural arches, and transverse processes (at the base) of the type lumbar of *Priscodelphinus stenus* are relatively greater. It is believed that these differences are of sufficient importance to justify the application of another name to the porpoise hereinafter described.

KENTRIODON, new genus[6]

KENTRIODON PERNIX, new species

INDIVIDUAL I

Type specimen.—Cat. No. 8060, Division of Vertebrate Palaeontology, United States National Museum. When this specimen was received at the museum, it was seen that the skeleton was fairly complete, with the skull, mandibles, cervical and dorsal vertebrae in their

[4] Cope, E. D., Synopsis of the Vertebrata of the Miocene of Cumberland County, New Jersey. Proc. Amer. Philos. Soc., vol. 14, p. 363. 1875.

[5] Cope, E. D., The Cetacea. American Naturalist, vol. 24, No. 283, p. 615. July, 1890.

[6] *Κέντριον*, diminutive of *Κέντρον*, prickle or spike; *ὀδών*=*ὀδούς*, tooth—in allusion to the pair of elongated teeth at the extremity of the rostrum and mandibles; *pernix*, swift or nimble.

natural positions. The skeleton was prepared in relief for exhibition and the elements lie in the position in which they were at the time they were buried by sediments. The porpoise lies on its left side and the vertebrae are in sequence from the atlas to the fifth lumbar. The vertebral column is not complete, but 7 cervicals, 10 dorsals, 4 lumbars, and transverse processes of 3 others, and 10 caudal vertebrae and an epiphysis of another, as well as 4 chevrons, are present. The vertebral column of this porpoise appears to consist of 48 vertebrae, divided as follows: 7 cervical, 10 dorsal, 10 (?) lumbar, and 21 (?) caudal vertebrae. On the right side there are 6 ribs in regular sequence and articulated with their respective vertebrae: 4 additional ribs lie on the right side of the vertebral column. On the left side, 10 ribs are present, but most of them are incomplete. With the exception of the posterior half of the left scapula and the proximal epiphysis of the right humerus, all of the bones of the fore limbs are missing. The skull is essentialy complete, but is crushed slightly; a relatively small number of the teeth are missing. Both mandibles, and both tympanic bullae and periotics are present. The right thyrohyal of the hyoids is preserved. This specimen appears to be immature for reasons hereinafter mentioned.

Locality.—The occurrence is as follows: Near Latitude 38° 40′ north, and longtiude 76° 32′ west, on the western shore of the Chesapeake Bay, approximately 1.5 miles south of Chesapeake Beach, Calvert County, Maryland. Shown on the Patuxent quadrangle or Patuxent folio, No. 152, United States Geological Survey.

Horizon.—This specimen was discovered and excavated by Norman H. Boss on July 5–7, 1913. It was dug from the face of the cliff about 5 feet above beach level in the greenish sandy clay of Shattuck's zone 5 of the Calvert Miocene formation of Maryland.

INDIVIDUAL II

Referred specimen.—Cat. No. 10670, Division of Vertebrate Paleontology, United States National Museum. The second specimen referred to this species consists of an imperfect and slightly crushed skull, with the extremity of the supraorbital process of the left frontal and overlying plate of the maxilla, as well as the left zygomatic process missing; both pterygoids are damaged. All of the teeth with the exception of three, both mandibles, and both tympanics and periotics are missing. This skull belonged to a mature individual.

Locality.—The occurrence is as follows: Near latitude 38° 40′ north, and longitude 76° 32′ west, on the western shore of the Chesapeake Bay, south of Chesapeake Beach, Calvert County, Maryland. Shown on the Patuxent quadrangle or Patuxent folio, No. 152, United States Geological Survey.

Horizon.—This skull was discovered and excavated by William Palmer during July, 1918. It was dug from the face of the cliff about 3 feet below the level of the oyster shells (*Ostrea percrassa*) in the bluish sandy clay of the upper part of Shattuck's zone 3 of the Calvert Miocene formation of Maryland.

Most of the characteristic porpoises which frequented the seas along the Atlantic Coast of North America during Miocene times disappeared from these waters near the close of that period, for they are not known from subsequent formations, and other species which were developing elsewhere took their places in the pelagic faunas of succeeding geological periods. We have no evidence that the fossil porpoise here described is ancestral to living propoises, like *Lissodelphis*, *Delphinus*, *Steno*, and *Prodelphinus*, but there is a marked resemblance between this fossil species and the living *Sotalia*. This fossil propoise undoubtedly belongs in the family Delphinidae, although it should not be placed in the same section with *Delphinus* and *Steno*, but rather with *Sotalia*. It does not represent, however. an intermediate stage between *Sotalia* and any other known fossil porpoise. The skeleton of this porpoise was approximately 5½ feet long.

The graceful undulating movements of some of the smaller Delphinidae are familiar to all who have observed a shoal of these animals in pursuit of a school of fish. The individuals in a shoal of porpoises often swim in a line one before another, never showing at the surface more than the dorsal fin and a small portion of their backs. At times they spring from the water and leap a considerable distance. The skeletons of the Miocene porpoises, *Delphinodon dividum* and *Kentriodon pernix*, resemble those of some of the smaller living porpoises very closely, and it is not unlikely that they were as active and as graceful as any of the living types. Judging by the skeletons of the fossil porpoises which are more or less fully known, there has been a tendency toward greater progressive changes in the structural modifications of some types than in others. In general these modifications have facilitated feeding and swimming. Less progressive, less active, and less plastic species of several types, particularly *Squalodon*, frequented the Miocene Chesapeake estuary at the same time as *Delphinodon dividum* and *Kentriodon pernix*. More highly modified and possibly more active species, like *Zarhachis flagellator*, *Eurhinodelphis bossi*, and *Schizodelphis crassangulum* also entered the same estuary.

Fish-eating porpoises predominate among the living Delphinidae, but there are some that feed largely on cuttlefish, squids, and crustaceans. That these Miocene porpoises differed from one another in their feeding habits is suggested by the modifications observed in the

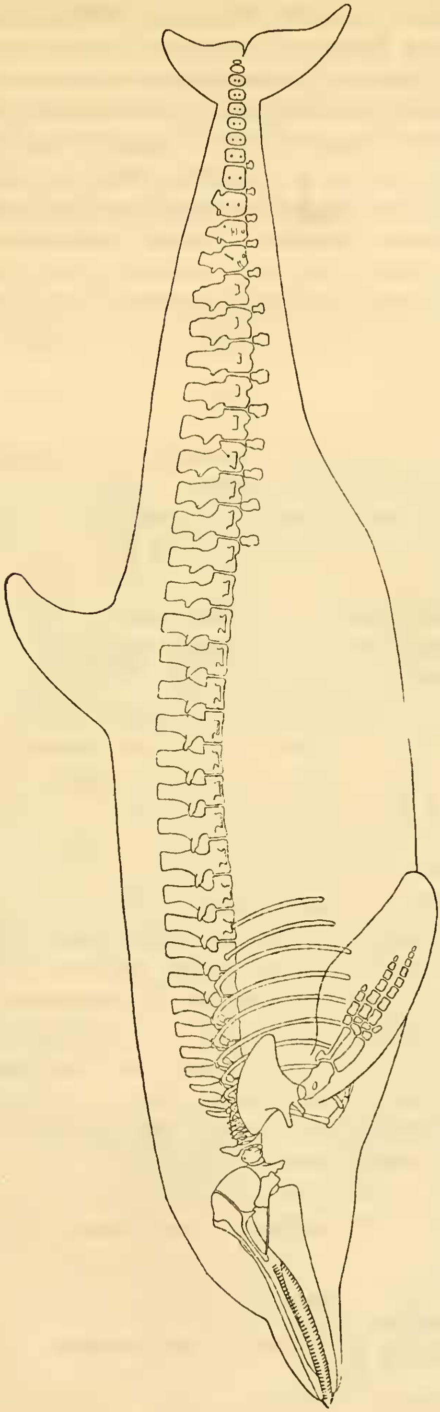


FIG. 5.—RESTORATION OF KENTRIODON PERNIX, ESTIMATED AS 5½ FEET IN LENGTH, A SMALL PORPOISE OF APPROXIMATELY THE SAME SIZE AS THE LIVING SOUTHERN PORPOISE, SOTALIA. THE BODY OUTLINE IN THIS RESTORATION IS HIGHLY CONJECTURAL

position and extent of the glenoid articular surface on the zygomatic process, the relative lengths of the upper and lower jaws, and the differences in the shape and proportions of the teeth. As a rule the progressive types of porpoises possess more simplified teeth and have a shorter and more compact cervical series than the generalized types. The cervical series is relatively short in both *Delphinodon dividum* and *Kentriodon pernix*, and the centra are short and flat. In case of *Delphinodon dividum*, the teeth are relatively large, with rugose enamel on the crown, and accessory cusps on the posterior ones; *Kentriodon pernix*, on the other hand, has slender teeth, with smooth enamel on the crown, but no accessory cusps were noted on any of the teeth.

SKULL

Aside from a narrower brain case and a more slender rostrum, the skull of *Kentriodon pernix* differs from that of *Delphinodon dividum*[7] in having approximately 40 teeth in the upper jaw and 38 in the lower whereas in *D. dividum* there are not more than 27 teeth in the upper jaw and 26 in the lower. With regard to the proportions and relations of the bones on the top of the brain case, the skull of *Kentriodon pernix* appears to agree more closely with the skull of *Acrodelphis* (*Phocaenopsis*) *scheynensis* (Du Bus) figured by Abel[8] than with any other Upper Miocene porpoise known to the writer. The skulls of *Kentriodon* and *Acrodelphis* resemble each other in the shape and proportions of the vertex, the form of the nasal bones, the relative size of the posterointernal angle of the frontal exposed on the vertex, the interval which separates the posterointernal angles of the cranial plates of the maxillae, the relations between the posterior extremities of the premaxillae and the nasal bones, and the curvature of the transverse crest of the supraoccipital. There are features, however, which indicate that these two fossil porpoises represent different types and of these the peculiarities of the premaxilla, particularly the greater width of this bone at the level of the antorbital notch in *A. scheynensis*, are the most obvious. If *Phocaenopsis scheynensis* actually belongs in the genus *Acrodelphis*, then *Kentriodon* also differs from that porpoise in the shape of the mandibles and the length of the symphysis.

The skull of *Kentriodon pernix* is of approximately the same size and the dental formula is similar to *Delphinavus newhalli*,[9] but Pro-

[7] True, F. W., Description of a new fossil porpoise of the genus *Delphinodon* from the Miocene formation of Maryland. Journ. Acad. Nat. Sci. Philadelphia, ser. 2, vol. 15, pp. 165–194, pls. 17–26. December 9, 1912.

[8] Abel, O., Les odontocètes du Boldérien (Miocène supérieur) d'Anvers. Mém. Mus. Roy. d'Hist. Nat. de Belgique, Bruxelles, vol. 3, p. 135, text fig. 20 and p. 137, text fig. 21. 1905.

[9] Lull, R. S., Fossil dolphin from California. Amer. Journ. Sci., New Haven, vol. 37, pp. 209–220, text figs. 1–7, pl. 8. March, 1914.

fessor Lull says that the premaxillary bone is toothless. It is not necessary to consider the skull of *Heterodelphis leiodontus* Papp [10] in this connection because the rostrum and mandibles of this porpoise are considerably longer than those of *Kentriodon pernix.*

The similarities and differences observable between the skulls of *Kentriodon pernix* and *Delphinodon dividum* are listed in the following tables for the convenience of those who may be interested in this subject.

Comparison of skulls of Kentriodon pernix and Delphinodon dividum Cope

DORSAL ASPECT

Delphinodon dividum True	*Kentriodon pernix*
Brain case very large, broad, and almost equal in length to rostrum.	Brain case short and narrow, about five-eighths as long as rostrum.
Rostrum relatively short, strongly attenuated, and not constricted at base.	Rostrum relatively long, slender, and slightly constricted at base.
Vertex small, more or less pentagonal..	Vertex small, more or less pentagonal.
Nasals relatively large, anterior margin concave, and depressed anteriorly.	Nasals relatively large, anterior margin deeply notched, and elevated anteriorly.
Apophysis of medium size, not conspicuously produced.	Apophysis large, conspicuously produced.
Antorbital notch shallow.	Antorbital notch deep and narrow.
Maxillary foramina situated anterior to antorbital notches.	Maxillary foramina situated posterior to antorbital notches.
Horizontally expanded cranial plate of maxilla not wider than premaxilla at level of anterior margin of respiratory passages.	Horizontally expanded cranial plate of maxilla wider than premaxilla at level of anterior margin of respiratory passages.
Premaxillae noticeably expanded posterior to antorbital notches.	Premaxillae not noticeably expanded posterior to antorbital notches.
Curvature of transverse crest of supraoccipital regular.	Curvature of transverse crest of supraoccipital irregular.

[10] Papp, C. von, Heterodelphis leiodontus nova forma aus den Miocenen Schichten des Comitates Sopron in Ungarn. Mitteil. Jahrb. Königl., Ungar. Geol. Anstalt, Budapest, vol. 14, Heft 2, pp. 25–60, pls. 5–6, text figs. 1–10, 1905.

Comparison of skulls of Kentriodon pernix and Delphinodon dividum Cope—Continued

LATERAL ASPECT

Delphinodon dividum True	*Kentriodon pernix*
Zygomatic process slender, about one-third as deep as long, and with anterior extremity obliquely truncated.	Zygomatic process robust, about one-half as deep as long, and with anterior extremity squarely truncatéd.
Temporal fossa much longer than anteroposterior diameter of supraorbital process at orbital border.	Temporal fossa equal to or but slightly longer than anteroposterior diameter of supraorbital process at orbital border.
Posterior extremity of maxilla not in contact with transverse crest of supraoccipital.	Posterior extremity of maxilla in contact with transverse crest of supraoccipial.
Lambdoid crest apparently undeveloped, and hence posterior boundary of temporal fossa is uncertain.	Lambdoid crest well developed, forming posterior boundary of temporal fossa.
Postorbital projection of supraorbital process long and slender.	Postorbital projection of supraorbital process long and slender.
Extremity of rostrum formed by premaxillae and 3 or more of the teeth on each side are lodged in this bone.	Extremity of rostrum formed by premaxillae and at least 8 of the teeth one each side are lodged in this bone.
Rostrum at base about two-fifths as deep as wide.	Rostrum at base about two-thirds as deep as wide.

VENTRAL ASPECT

Delphinodon dividum True	*Kentriodon pernix*
Palatines of large size, in contact along midline, and extend forward beyond level of antorbital notches. Each palatine is characterized by a deep anterolateral emargination and large posterior depression.	Palatines lodged in elongate depressions in front of respiratory passages and extend forward beyond level of antorbital notches.
Inner margins of maxillae diverge at a point 50 mm. in front of antorbital notches, exposing a broad strip of the vomer for a distance of not more than 90 mm.	Inner margins of maxillae slightly separated at a point 60 mm. in front of antorbital notches, allowing axial ridge of vomer to appear between them for a distance of not more than 40 mm.
Palatal surface of each maxilla excavated at base of rostrum, forming a well-defined concavity.	Palatal surface of each maxilla slightly excavated at base of rostrum, but not forming a distinct concavity.
Lachrymal large, extending inward beyond inferior orifice of infraorbital canal, and closely appressed to anterior margin of supraorbital process frontal.	Lachrymal large, extending inward beyond inferior orifice of infraorbital canal, and closely appressed to anterior margin of supraorbital process of frontal.

Comparison of skulls of Kentriodon pernix and Delphinodon dividum Cope—Continued

VENTRAL ASPECT—continued

Delphinodon dividum True	*Kentriodon pernix*
Jugal small, ankylosed to lachrymal posteriorly, and mortised into ventral surface of maxilla internal to antorbital notch; styliform process noticeably enlarged as it approaches body of jugal.	Jugal small, ankylosed to lachrymal posteriorly, and mortised into ventral surface of maxilla internal to antorbital notch; styliform process exceedingly slender, not enlarged as it approaches body of jugal.
Internal surface of each falcate process of the basioccipital characterized by an oblique ridge which extends from near anterior margin to postero-inferior angle.	Internal surface of each falcate process of the basioccipital rather evenly convex, no ridge.
Zygomatic process and glenoid articular facet narrow, but the internal margin is undercut and is set off posteriorly by an excavation on ventral surface of squamosal.	Zygomatic process and glenoid articular facet wider, and the internal margin is strongly undercut and set off posteriorly by an excavation on ventral surface of squamosal.
Not more than 27 teeth on each side; the largest teeth 29 mm. in length and 5 mm. in diameter; the smallest teeth 20 mm. in length and 4 mm. in diameter.	At least 40 teeth on each side, the anterior one noticeably larger than others and projects forward and downward from extremity of premaxilla; the largest teeth 38.3 mm. in length and 3.9 in diameter; the smallest teeth 13 mm. in length and 2.8 mm. in diameter.
Crowns of teeth recurved, with rugose enamel, and a distinct carina on anterior and posterior cutting edges; posterior teeth with one or more accessory cusps; roots slender, gibbous below crown, and have a large dentinal canal.	Crowns of teeth recurved, with relatively smooth enamel, but with neither carinae nor accessory cusps; roots slender, slightly enlarged below crown, and have a small dentinal canal.

Dorsal view.—As seen from the dorsal side the skull (pl. 2) of this porpoise differs markedly from that of *Delphinodon dividum;* the most noticeable peculiarities are its long and attenuated instead of rapidly tapering rostrum, less expanded premaxillae in the region of the respiratory passages, deeper antorbital notches, and narrower cranium, although the horizontally expanded posterior extremities of the maxillæ are relatively wider. The form of the base of the rostrum appears to be quite characteristic, since both skulls exhibit the same peculiarities. In accordance with the usual method of description the rostrum is considered to commence at the antorbital notches which are bounded externally by the broad apophyses of the maxillae. In front of the antorbital notches the exposed portions of the maxillae are somewhat narrower than the premaxillae. The premaxillae are more or less horizontal on the base of the rostrum, but in front of the antorbital notches they commence to slope more and more from the inner to the outer margin and on the distal one-third of the rostrum are almost vertical; they decrease in breadth but increase in height toward the extremity of the rostum. The inner margins of the premaxillae are almost in contact with one another in front of the respiratory passages for a distance of about 15 mm. and, after spreading apart, gradually converge again up to a point 90 mm. in front of the antorbital notches, and then diverge even more widely than on the basal half of the rostrum. The premaxillae commence to expand horizontally near the middle of the rostrum and attain their maximum breadth at the level of the anterior border of the respiratory passages. Opposite to these passages each premaxilla is raised above the corresponding maxilla and the outer border slopes to the maxillary suture. The posterior extremity of each premaxilla is bluntly acuminate and meets the antero-external face of the five-sided nasal edge to edge. The premaxillary foramina are rather large and are situated posterior to the antorbital notches and anterior to the maxillary foramina. Two narrow grooves lead from each of these premaxillary foramina, one of which extends obliquely forward to the internal margin; the other, a much deeper groove, curves backward and outward and is continued posteriorly for some distance along the external margin of the premaxilla. Anterior to the premaxillary foramen the internal portion of the premaxilla is set off from the external border by the first-mentioned groove; this triangular strip narrows rapidly and finally disappears in consequence of the arching of this bone.

With the exception of a short interval in front of the respiratory passages where the inner margins of the premaxillae are almost in contact, the mesorostral gutter is open for its whole length. On the distal end of the rostrum the premaxillae meet mesially and ventrally in a linear suture and form the floor and sides of the mesorostral gutter; on the proximal half the vomer and premaxillae contribute to its formation. The vomer increases in width from its anterior end to the respiratory passages and near the proximal end of the mesorostral gutter rises to the level of the pluglike presphenoid.

As in the living southern porpoise, *Sotalia tucuxi* (Cat. No. 21499, United States National Museum), the mesethmoid is limited to the mesial longitudinal strip of bone which constitutes the most dorsal portion of the wall between the respiratory passages and the sutures which mark its contact with the laterally placed ectethmoids have disappeared. These sutures likewise disappear with age in living porpoises. A continuous sheet of bone extends upward, overspreading the lower borders of the anterior faces of the nasals and the internal borders of the more or less vertical plates of the frontals, and closes over the area through which the olfactory nerves originally found passage. The mesethmoid is incomplete but probably did not rise to the level of the premaxillae as on the skull of *Sotalia tucuxi*. This continuous sheet of bone, consisting of the ectethmoids and the mesethmoid, also sheathes the dorsal and the upper halves of the lateral faces of the presphenoid and on the inner wall of each respiratory passages meets the corresponding margin of the troughlike vomer in which the presphenoid rests edge to edge.

A slitlike anterior border for the combined respiratory passages is formed by the close approximation of the internal margins of the premaxillae. As mentioned previously, the premaxillae approximate each other so closely behind the premaxillary foramina that they roof over the mesorostral gutter and conceal the anterior extremity of the presphenoid. The presphenoid appears to be rather porous and forms a plug at the proximal end of the mesorostral gutter, but does not rise to the level of the premaxillae above. This pluglike bone projects above the premaxillae on the skull of *Sotalia tucuxi*.

The maxillae and premaxillae constitute the major portion of the dorsal surface of the skull. The antorbital notches are moderately deep and the rostrum appears to be constricted slightly at the base. For a distance of approximately 50 mm. in front of the antorbital notch the outer margin of the maxilla is rounded off. Farther forward this rounded edge disappears with the lateral compression of the rostrum, and the maxilla appears to be deeper from a side view. As a result of the attenuation of the rostrum, the maxilla decreases in breadth anteriorly and the sides slope obliquely downward. The maxilla is barely visible from a dorsal view on the distal one-third of the rostrum. Posterior to the antorbital notch the maxilla expands horizontally and overspreads the frontal bones; the maximum width is attained opposite to the nasal bones. The posterior margins of the maxillae are in contact with the transverse crest of the supraoccipital and the posterointernal angles curve upward, but do not quite reach the level of the dorsal surfaces of the nasals. The thin platelike posterior extremities of the maxillae and the corresponding underlying lateral extensions of the frontals roof over the temporal fossae. On the second skull (pl. 6) the outer margins of both maxillae are imperfect above the temporal fossae, but are essentially complete on the first skull (pl. 2). As regards curvature each maxilla is somewhat depressed opposite to the nasals and slightly convex above the supraorbital process of the frontal; the concaveness is most evident above the temporal fossa. One large or two small foramina which connect with the infraorbital system are present in each maxilla above the temporal fossa and when two are present the posterior one is the largest. Behind the antorbital notch one or two maxillary foramina, smaller than those in the premaxillae, open into the shallow grooves which lead forward.

On comparing the dorsal surface of the skull of *Sotalia tucuxi* with that of *Kentriodon pernix*, it was noted that it differed from the latter in that the horizontal cranial plates of the maxillae are relatively wider and that they do not completely sheath the frontals, for there is a narrow strip exposed between their posterior extremities and the transverse crest of the supraoccipital; the brain case is relatively larger and the rostrum is not as slender. Returning again to the skull of *Kentriodon pernix* it may be noted that the horizontal plate of the maxilla does not completely cover the supraorbital process of the frontal, and a narrow strip of the outer margin is exposed above the orbit. In front of the orbit the anteroexternal angle of each maxilla is produced, forming an apophysis. The apophysis of the maxilla is large and broad, projecting beyond the anterior margin of the supraorbital process and overspreading the lachrymal. The lachrymal is closely appressed to the supraorbital process of the frontal and is barely visible from a dorsal view.

From a dorsal view the frontals are largely concealed by the overspreading cranial plates of the maxillae and the slender premaxillae. They are suturally united posteriorly with the supraoccipital, and no trace of an interparietal could be found on either of the skulls. Mesially the frontals meet edge to edge on the vertex and are overspread anteriorly by the nasal bones. The vertex is elevated, relatively small in area, hexagonal in outline, and is formed by the frontals and nasals. On the vertex the posterointernal angle of each frontal is exposed, forming a six sided area of smaller size than the corresponding nasal. Laterally, each frontal sends out a thin platelike extension which underlies the horizontally expanded cranial plate of the maxilla and contributes the roof for the temporal fossa. Farther forward this portion of the frontal is considerably thickened and arched to form a complete osseous roof for the orbit.

The nasals are rather large, more or less six-sided bones which bound the posterior margin of the entrance to the combined respiratory passages. As regards shape, the nasals on both skulls resemble each other so closely that they in conjunction with other features may be said to characterize this species. The anterior margin of each nasal bone is deeply notched and the posteroexternal angle is drawn out into a sharp projection.

Posterior view.—Notwithstanding the distortion produced by the dorso-ventral crushing of the brain case, the original shape of the posterior surface is fairly obvious. The back of the brain case (pl. 3, fig. 1) was inflated, but possibly not as much as in *Sotalia tucuxi.*

The walls of the brain case were too thin to withstand crushing and the supraoccipital bone fractured in many directions. It also buckled backward above the foramen magnum, and the amount of crushing or displacement above the center of the upper margin of this foramen may equal 15 mm. The posterior face of this fossil skull resembles that of *Sotalia tucuxi* more closely than that of *Delphinodon dividum*, but differs from both in that the transverse crest of the supraoccipital is essentially three-sided, the median strip (25 mm.) being coextensive with the vertex at the rear, and each of the lateral strips (46 mm.), which form an obtuse angle with the median strip, are nearly twice as long. In *Sotalia tucuxi* the transverse crest of the supraoccipital is essentially two-sided, with the apex behind the median suture between the frontals.

The supraoccipital is wider than high, more or less hexagonal in outline, but is without a median carina on the upper portion; each lateral lambdoid crest, a continuation of the transverse crest, follows the natural curvature of the posterior end of the temporal fossa. Along the posteroinferior border of the temporal fossa the lambdoid crest overhangs the exoccipital as in *Sotalia tucuxi.*

On the second skull (pl. 3, fig. 1) the paroccipital processes are prolonged downward at least 12 mm. below the level of the inferior borders of the falcate processes. Reversed conditions are found on the skull of *Sotalia tucuxi* where the falcate processes project below the paroccipital processes. In *Sotalia* the external margin of the exoccipital is almost vertical, the ventral angle is blunt and rounded off, and the jugular incisure is broad. Although the outer margin of the exoccipital is incomplete on both sides of this fossil skull, it is evident that it is truncated obliquely, the ventral angle curves inward, and the jugular incisure is deep and narrow. The exoccipitals do not completely conceal the squamosals from the rear.

The foramen magnum is slightly higher than wide. Each occipital condyle is considerably broader near the middle than near the top and tapers rapidly to the lower extremity. The internal margins of the condyles are concave and are sharply defined; the external margins are set off from the surrounding bone by a continuous shallow depression. The articular surface of each condyle curves moderately from end to end and slopes forward from internal to external margin.

Lateral view.—Aside from a slender rostrum and a small brain case, the skull as viewed from the side (pl. 5, fig. 1) is characterized by a more or less rectangular zygomatic process, a large orbit, and the presence of at least 40 slender teeth in each jaw, of which 32 are lodged in the maxilla and 8 in the premaxilla. A tooth much larger than the others projects forward and slightly downward from the extremity of the premaxilla. In *Sotalia tucuxi*, not more than 2 of the anterior teeth are lodged in the premaxilla. Judging from these two skulls some variation in the relative lengths of the rostra may be expected inasmuch as the measurements show that in case of the first skull (pl. 5, fig. 1) it is equivalent to about three-fifths of the total length while in the second skull (pl. 5, fig. 2) it is almost three-fourths of the total length. As regards relative depth the rostrum agrees with that of *Sotalia tucuxi*. At the base the rostrum is about two-thirds as deep as wide. For approximately 50 mm. in front of the antorbital notch the outer border of each maxilla is rounded off and the upper surface is flat and almost horizontal. Beyond this basal section the slope of the upper surface of the maxilla is from the premaxillary suture to the alveolar margin, becoming steeper as the maxilla decreases in depth and near the extremity is almost vertical. Near the middle of the rostrum the dorsolateral face of the maxilla is deeper than the premaxilla, but from this point forward it gradually diminishes in height while the premaxilla increases. The extremity of the rostrum is formed entirely by the premaxillae. From a lateral view the alveolar gutter is barely visible throughout its length and on the right side terminates 16 to 18 mm. in advance of the antorbital notch. The axis of the rostrum is approximately horizontal and the basicranial axis is bent downward from that of the rostrum.

The anterior margins of the nasal bones are the highest points on the dorsal profile; from these bones to and slightly beyond the antorbital notches, the premaxillae slope strongly downward. The maxillae, on the other hand, slope more gradually from the transverse crest of the supraoccipital to the base of the rostrum.

On its external border the supraorbital process of the frontal is rather thin. The anterior angle or preorbital process is a slight enlargement, about 14 mm. in depth, but the posterior angle or postorbital projection is prolonged downward, forming a slender projection which did not come in contact with the zygomatic process. As a result of crushing in a dorsoventral direction, the postorbital projection on the second skull (pl. 5, fig. 2) was appressed to the anterior face of the right zygomatic process, while the first skull (pl. 5, fig. 1) was crushed in a more oblique direction and an interval of 20 mm. separates the above-mentioned processes on the right side. The maximum length of the right supraorbital process of the first skull (Cat. No. 8060) is 59 mm. and that for the second skull (Cat. No. 10670) is 60 mm.

The large lachrymal bone is closely appressed to the anterior face of the supraorbital process and is overspread above by the apophysis of the maxilla. Below the antorbital notch the small wedgelike jugal is fused posteriorly with the lachrymal and its basal portion is deeply mortised into the maxilla. An extremely slender and almost threadlike styliform process of the jugal extends below the orbit from the antorbital notch to the anterior face of the zygomatic process. On the first skull, the styliform process of the jugal (pl. 4) is preserved in its entirety on the right side, but in consequence of crushing has been slightly displaced from its original position and now rests superimposed upon the coronoid border of the mandible.

Originally the temporal fossa was somewhat smaller than at present (pl. 5, fig. 2) and taking crushing into consideration it is apparent that its maximum length was not much greater than one- and one-half times the length of the orbit. Superiorly the temporal fossa is bounded by the thin platelike lateral extension of the frontal which underlies the maxilla and posteriorly by the lambdoid crest which follows the lateral margin of the supraoccipital. In this fossa the parietal is suturally united anteriorly and superiorly with the frontal, posteriorly with the supraoccipital, and inferiorly with the alisphenoid and squamosal. In shape the parietal bears some resemblance to a boot. It is clearly excluded from the dorsal surface of the skull.

As compared to that of *Delphinodon dividum*, the zygomatic process is shorter and deeper; it is thickened dorsoventrally and the anterior extremity is rather squarely truncated. The ventral margin is more strongly curved than the dorsal; the postglenoid process is short and rounded. The greatest length of the zygomatic process of the second skull (Cat. No. 10670) along the glenoid border is 41.8 mm. and the greatest depth of the anterior extremity is 18.5 mm. The condyles project posteriorly beyond the level of the exoccipitals.

Ventral view.—In addition to those characters which distinguish it from both *Delphinodon dividum* and *Acrodelphis scheynensis* the skull of *Kentriodon pernix* may also be recognized by certain structural peculiarities which can only be seen from a ventral view. Of these the deep elongate depression in front of each respiratory passage for the reception of the palatine, the relative width of the zygomatic process, and the number of alveoli for teeth are probably the most conspicuous. As seen from below the skull of the second individual (pl. 7) differs from *Sotalia tucuxi* mainly in the shape and relations of the lachrymal bone.

Inasmuch as the right mandible is crushed against the palate of the skull associated with the skeleton (pl. 4) it did not appear advisable to attempt any further removal of matrix in order that the ventral surface of the rostrum could be studied. Hence this part of the description will be based on the second skull (pl. 7) with such additions and corrections as may be ascertained from the portions of the above-mentioned skull already exposed. The ventral surface of the rostrum is formed almost entirely by the maxillae which meet mesially in a linear suture at the level of the anterior margins of the palatines and continue forward in contact for a distance of 45 mm. where they separate to allow the axial ridge of the vomer to appear between them. Something like 32 teeth were lodged in each maxilla and 8 in each premaxilla, of which the most anterior one is greatly elongated and projects forward. The extremity of the rostrum of the second skull is missing and the premaxillae are not visible from a ventral view on that portion of the rostrum which is preserved. The maxillae broaden from their anterior extremities to the antorbital notches. The convexness of the ventral surface of each maxilla between the tooth rows coincides almost exactly with the obliquity of the dorso-lateral surface and the concaveness of the basal portion is coextensive with the rounded outer border. The ventral orifice of the infraorbital canal is bounded by the maxilla and lachrymal.

The lachrymal is elongate, ankylosed to the anterior margin of the supraorbital process of the frontal, and contributes the posterior and outer borders of the ventral orifice of the infraorbital canal; it is sheathed dorsally by the apophysis of the maxilla and is separated by an interval of not more than 9 mm. from the extremity of the orbitosphenoid. In conjunction with the jugal it forms the lower border of the antorbital notch. Below this notch the lachrymal is so intimately fused with the jugal that the exact limits of these two bones can not be determined. As regards shape and relations with the surrounding bones, the lachrymal bears a much closer resemblance to that of *Delphinodon dividum* than to *Sotalia tucuxi*. The skulls of a number of living porpoises, particularly *Steno rostratus*, *Lissodelphis borealis*, and *Delphinus delphis*, all have a lachrymal like that of *Sotalia*, but curiously enough *Phocaena phocœna*, whose skull otherwise is quite unlike these fossils, has a lachrymal of this type.

Fortunately the entire styliform process of the right jugal is preserved on the first skull. (Pl. 4.) The anterior extremity of the jugal consists of a small more or less triangular body, which is deeply mortised into the ventral surface of the maxilla internal to the antorbital notch and its posterior margin is ankylosed to the large lachrymal bone. From the body of the jugal a long slender and almost threadlike styliform process projects backward below the orbit and probably was attached originally by a ligament to the anterior extremity of the zygomatic process.

When the skull of *Kentriodon pernix* is contrasted with skulls of living porpoises, especially *Sotalia tucuxi*, *Lissodelphis borealis*, *Steno* *rostratus*, and *Delphinus delphis*, attention is at once directed to the similar relationships existing between the bones surrounding the inferior borders of the respiratory passages. Briefly stated, the relations and structural peculiarities of the palatines, pterygoids, and maxillae appear to be more nearly in agreement with *Sotalia tucuxi* than with any other living porpoise in the family Delphinidae. With the exception of a small fragment of that portion of the thin ascending plate of the palatine which overspreads the pterygoid in front of the supraorbital process, both palatines are destroyed. The sutures which mark the original position of the palatines are well defined and show that they were similar to those of *Sotalia tucuxi*. In the latter each palatine bone overspreads the elongate depression in front of the corresponding respiratory passage and is suturally united anteriorly and externally with the maxilla. Viewed from the side, the palatine is prolonged upward as a thin ascending plate, which overlaps the pterygoid and abuts superiorly against the horizontally expanded cranial plate of the maxilla. This thin ascending plate of the palatine does not appear to have touched the orbitosphenoid as in *Sotalia tucuxi*. When the palatines are in their normal positions the elongate depressions are not exposed to view. In the skull of this living porpoise the palatines meet mesially and project forward beyond the level of the antorbital notches.

Upon comparing the skulls of *Sotalia*, *Steno*, *Lissodelphis*, and *Delphinus* with these two fossil skulls it became apparent that each pterygoid in the latter consisted of a single internal plate, which straddles the external margin of the basisphenoid and internally meets the horizontally expanded extremity of the vomer edge to edge. The anterior extremity of the thin internal plate of each pterygoid curves around the outside of the corresponding respiratory passage, forming that much of the lower border, and unites by suture with the palatine below and the vomer above on the anterior wall of that passage. In *Sotalia tucuxi* the thin internal plate of the pterygoid is continuous anteriorly with a short external reduplication, which in turn united with the above-mentioned thin ascending plate of the palatine. There is a small airspace or sinus between these two plates. No portion of the pterygoid comes in contact with the alisphenoid.

The vomer first makes its appearance on the ventral surface of the skull about 60 mm. in front of the antorbital notches as a narrow ridge separating the inner margins of the maxillae and is exposed to view for a distance of not more than 40 mm. In front of and posterior to this region the inner margins of the maxillae are in contact and exclude the vomer from the ventral surface of the rostrum. The thin keel of the vomer again makes its appearance near the level of the anterior extremities of the palatines and increases in depth posteriorly, attaining its maximum near the center of the respiratory passages. The vomer expands horizontally posterior to the respiratory passages, overspreads the anterior border of the basisphenoid, and externally meets the internal plate of the pterygoid edge to edge. Inferiorly the posterior wall of each respiratory passage is thus lined by the vomer and the internal plate of the pterygoid; the lower external border is formed entirely by the pterygoid and the internal wall by the vomer; the palatine and pterygoid both contribute to the formation of the anterior wall. The construction and relations of the various bones entering into the upper limits of each respiratory passage are discussed in the description of the dorsal surface.

The median region of the basicranium widens posteriorly and is similar in shape to that of *Sotalia tucuxi.* It is bounded on each side by a continuous wall formed by the internal plate of the pterygoid anteriorly and by the falcate process of the basioccipital posteriorly. The surface of the median area between these lateral walls is slightly concave. The basioccipital is a much wider bone than the basisphenoid, but the suture between these two bones is very indistinct. The posterior extremities of the falcate processes are slightly thickened and are rounded off. The occipital condyles are large and are separated mesially by a deep groove. Between the internal margin of the exoccipital and the posterior margin of the laterally placed falcate process of the basioccipital there is a deep jugular incisure for the passage of the blood vessels comprising the so-called "jugular leash." The ectal orifice of the small hypoglossal foramen appears on the posterior face of the exoccipital above the apex of the jugular incisure. The lower border of the exoccipital is prolonged downward and is slightly thickened to form the paroccipital process. In outline the facet on this process is crescentic and is relatively wider than in *Sotalia tucuxi.*

The body of the squamosal overspreads the parietal and appears to be excluded internally from the lateral wall of the brain case, since the lower border of the parietal makes its appearance below and internal to it on the external border of the tympanoperiotic recess. The squamosal, however, is firmly attached to the lateral surface of the parietal and its lateral projection or zygomatic process serves as the articular surface for the condyle of the lower jaw. The glenoid articular surface on the inferior face of the zygomatic process is strongly concave, curving upward and forward. The facet is relatively wider than in *Delphinodon dividum.* The external border of the glenoid facet follows the curvature of the zygomatic process, but the internal margin is set off posteriorly by a rather deep excavation on the squamosal which undercuts the facet to a more noticeable extent than in *Sotalia tucuxi.* This fossil skull agrees with that of

Sotalia tucuxi in the manner in which the ventral surface of the squamosal is excavated and probably also in the shape and direction of the thin projecting falciform process which has been destroyed. This falciform process probably projected inward and forward as in *Sotalia;* between the base of this process and the temporal angle of the alisphenoid is the semiinclosed foramen ovale. The postglenoid process is small and slightly thickened. A narrow deep groove for the external auditory meatus traverses the squamosal behind the postglenoid process. A posteriorly directed process of the squamosal is suturally united with the exoccipital along its posterior border. The periotic was attached by ligaments to the squamosal at the origin of the groove for the external auditory meatus. The tympanoperiotic recess is bounded by the squamosal externally, the exoccipital posteriorly, the falcate process of the basioccipital internally, and by the falciform process of the squamosal anteriorly; the projecting lower border of the parietal, the backwardly projected alisphenoid, and the underlying process of the basioccipital contribute a complete roof for this recess. Unfortunately a portion of the roof of the tympanoperiotic recess has been destroyed on the right side, so it is not possible to check conditions observed in the opposite recess. Nevertheless, the roof of the recess on the right side appears to be normal, without any irregularities produced by crushing, and agrees, furthermore, in all essential details with conditions observable on the skull associated with the skeleton. Probably the most noticeable peculiarity is the large posterior lacerated foramen which measures 9 mm. in diameter; there are no separate compartments for the nerves and blood vessels. The ectal orifice of this foramen is situated fully 28 mm. above the lower margin of the falcate process of the basioccipital. At the base of the falcate process and near the posterior margin of the pterygoid is the small ectal orifice of the canal for the carotid artery. The mandibular branch of the trigeminal nerve issues through a cleft on the posterior border of the alisphenoid and crosses the ventral surface of the latter on its outward course, although the usual groove is poorly defined.

The alisphenoid is a narrow bone which curves outward and upward, and is suturally united with the parietal above, the frontal in front, and on the rear with the squamosal externally and the parietal internally. Farther forward the orbitosphenoid projects obliquely forward and its extremity is applied to the ventral surface of the supraorbital process. As in *Sotalia tucuxi*, the orbitosphenoid forms the lower portion of the anterior wall of the brain case. The sphenoidal fissure appears to have been closed by the overlapping of the orbitosphenoid by the alisphenoid. Comparison with *Sotalia* shows that the optic nerve passed outward through a notch on the posterior border of the orbitosphenoid in both. The outward course of the optic nerve is marked by a deep groove which traverses the ventral surface of the orbitosphenoid to its extremity. Beyond the orbitosphenoid the optic nerve followed the channel on the supraorbital process of the frontal. The position of the foramen rotundum is uncertain.

Measurements of the skull (in millimeters)

	Cat. No. 8060 U.S.N.M.	Cat. No. 10670 U.S.N.M.
Total length (occipital condyles to extremity of rostrum)	298	318+
Length of rostrum (antorbital notches to extremity)	185	199
Breadth of skull across zygomatic processes of squamosals	x	[1] 142
Height of skull (between inferior margin of falcate process of basioccipital and dorsal surface of nasal bone)	73. 8	85
Height of skull (basisphenoid to nasal bones)	50. 5	61
Greatest breadth of skull across supraorbital processes (anteriorly)	116. 4	[1] 117
Occipito-premaxillary length of skull (posterior margin of maxilla to extremity of rostrum)	277	287+
Greatest distance between outside margins of premaxillae opposite respiratory passages	47	52. 5
Greatest breadth of right premaxilla in front of respiratory passages	22. 5	25. 2
Greatest breadth of right premaxilla at antorbital notch	15. 5	18. 2
Breadth of rostrum at level of antorbital notches	68	65
Greatest breadth of rostrum at anterior extremities of maxillae	17. 5	17. 5
Greatest length of cranial plate of right maxilla	88	90
Greatest width of cranial plate of right maxilla	42. 5	50
Distance between inner margins of maxillae at vertex	25	26. 5
Greatest breadth of supraorbital process of right frontal (preorbital margin to extremity of post-orbital projection)	56	59. 5
Greatest thickness of frontal and maxilla combined on outer margin and near center of orbit	6	6
Maximum width of exposed portions of combined frontals on vertex	23. 5	25. 5
Greatest anteroposterior diameter of exposed portion of right frontal on vertex	14	12. 2
Greatest anteroposterior diameter of right nasal	18. 5	20. 5
Greatest transverse diameter of right nasal	19	17. 2
Least breadth of cranium between temporal fossae	x	88±
Distance from center of transverse crest of supraoccipital to upper margin of foramen magnum	x	58+
Height of foramen magnum (as preserved)	x	21. 5
Width of foramen magnum (as preserved)	23	26. 5
Greatest distance between outer margins of occipital condyles	48	54. 2
Greatest height of right condyle	x	31
Greatest breadth of right condyle	17	21. 2
Greatest length of right zygomatic process	41. 1	41. 8
Greatest length of styliform process of right jugal	60. 4+	x
Greatest distance between outside margins of exoccipitals	108	113. 5
Greatest vertical depth of skull in front of respiratory passages	40	47. 7
Distance across median region of basicranium between posterior extremities of falcate processes of basioccipital	55	60. 3
Distance across median region of basicranium between posterior extremities of internal plates of the pterygoids	x	37. 5
Distance from proximal alveolus to distal alveolus, inclusive, on right side of the rostrum	171. 5	189+

[1] Estimated.

PERIOTIC

Aside from its smaller size, the left periotic (pl. 3, figs. 2–4) differs from that of *Delphinodon dividum* in that the *pars cochlearis* is less expanded horizontally, the *tractus spiralis foraminosus* is longer and the curvature of the spiral is less pronounced, the *fossa incudis* is narrower, the elongate foramen singulare is placed on the rim of the low partition between the spiral tract and the entrance to the *Aquaeductus Fallopii*, and there is a well-defined concavity on the ventral surface of the *pars cochlearis* at the anteroexternal angle. No periotics of the living southern porpoise *Sotalia* were available for comparison. Van Beneden figured two views of the right periotic of *Sotalia guianensis*. Judging from the illustrations used by Van Beneden[11] the periotic of *Sotalia* resembles this fossil periotic rather closely; the configuration of the cerebral surface and the shape of the internal acoustic meatus are similar, but they differ from one another in the positions of the entrance to the *Aquaeductus Fallopii* and the cerebral orifice of the *Aquaeductus cochleae*. Although this periotic is approximately the same size as that of the living porpoise *Prodelphinus malayanus* (Cat. No. 36051, U.S.N.M.), it differs from the latter in several respects, of which the shape of the internal acoustic meatus and the articular facet on the posterior process are probably the most obvious differences.

One characteristic feature of the ventral surface of this periotic (fig. 6) is the shape of the articular facet on the posterior process. This articular facet is deeply concave on the basal portion and the surface slopes from the apex to the internal margin. A few faint shallow grooves may be distinguished on the outer border of this facet, but they gradually disappear as they approach the above-mentioned concavity. The ventrointernal border of the posterior process projects inward and the free edge contributes the floor for the facial canal. The anterior face of the posterior process is excavated; the external face is somewhat flattened; and the posterior face is rather evenly convex.

As regards the ventral aspect of the *pars cochlearis*, there is a much closer resemblance to *Prodelphinus malayanus* than to *Delphinodon dividum*. The continuation of the facet for the accessory ossicle or uncinate process of the tympanic, usually limited to the anterior process, over upon the ventral surface of the *pars cochlearis* is an unusual modification. Nothing quite like this has been noticed on the periotics of living porpoises. The *pars cochlearis* of this fossil periotic also differs from those of both *Prodelphinus malayanus*

[11] Van Beneden, P. J., and P. Gervais, Ostéographie des Cétacés vivants et fossiles, Paris, Atlas, pl. 41, figs. 8, 8*a*, 1880.

and *Prodelphinus longirostris* (Cat. No. 21168, U. S. N. M.) in that the ventral surface is inflated more noticeably between this facet and the fenestra rotunda, forming an indistinct transverse crest, to the outside of which is a shallow concavity which slopes to the fenestra ovalis, and to inside is a slightly convex surface which slopes forward and inward. The fenestra rotunda is a subtriangular in outline and is slightly larger than the fenestra ovalis. A slight swelling is developed on the posterior face of the periotic above the fenestra rotunda which does not appear to have any relation to the aqueduct of the cochlea. The foot plate of the stapes completely fills the ovoidal fenestra ovalis and is held in position by a pair of narrow internal ledges which extend across the anterior and posterior walls, respectively. Within the vestibule are the orifices of three small canals, the largest of which are situated opposite to the epitympanic orifice of the *Aquaeductus Fallopii* and lead to the semicircular canals; the other, a minute orifice, is situated at the posterointernal angle and is the terminus of the aqueduct leading from the foramen singulare. On the internal wall there is a small passage which leads into the scala vestibuli. The epitympanic orifice of the *Aquaeductus Fallopii* is small and the narrow groove for the facial nerve, which leads from it, is sharply defined between the rim of the fenestra ovalis and the projecting ledge for the *fossa incudis*, but posterior to them it follows along the internal face of the posterior process to the posterior angle. A continuous thin-edged crest extending from the epitympanic orifice of the *Aquaeductus Fallopii* to the *pars cochlearis* separates the rim of the fenestra ovalis on outside from the groove for the facial nerve and on the rear from the fossa for the stapedial muscle. The elongate fossa for the stapedial muscle is rather deep, concave from side to

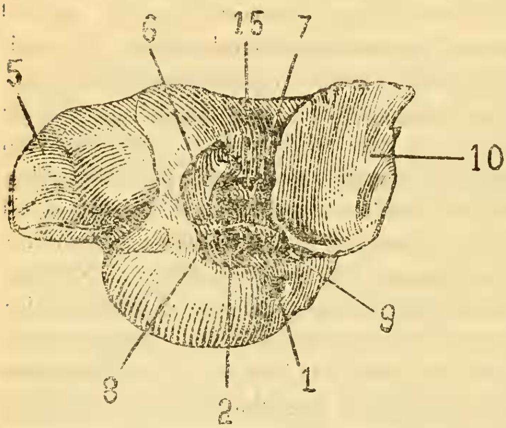


Fig. 6.—Ventral or Tympanic View of Left Periotic of Kentriodon pernix. × 2. Cat. No. 8060, U.S.Nat.Mus. The Same Numbers are Used on Figures 6 and 7 for the Following Structures: 1, Fenestra Rotunda; 2, Fenestra Ovalis; 3, Cerebral Orifice of Aquaeductus Cochleae; 4, Cerebral Orifice of Aquaeductus Vestibuli; 5, Processus Anterior Petrosi; 6, Fossa for Head of Malleus; 7, Semiclosed Canal for Facial Nerve; 8, Epitympanic Orifice of Aquaeductus Fallopii; 9, Fossa for Stapedial Muscle; 10, Processus Posterior Petrosi (Mastoid Process, in Part); 11, Internal Acoustic Meatus; 12, Foramen Centrale; 13, Foramen Singulare; 14, Entrance to Aquaeductus Fallopii; 15, Fossa Incudis

side, and extends downward upon the external face of the *pars cochlearis.* Along the internal margin of this fossa a thin-edged crest is developed on the ventroexternal angle of the *pars cochlearis* which extends backward to the posterior margin. In position and shape the stapedial fossa of this fossil periotic is essentially the same as on the periotic of *Prodelphinus malayanus.* The depth of the posterior face of this fossil periotic (7.1 mm.), as measured from the stapedial fossa to the fossa for the cerebral orifice of the *Aquaeductus vestibuli*, however, is almost twice that of the living porpoise (3.9 m.).

Between the rounded tuberosity or swelling on the basal portion of the anterior process and the anterior margin of the articular facet on the posterior process the ventral surface of the external denser portion of the periotic is deeply excavated. The raised external margin of the *fossa incudis* shuts off this excavation from the epitympanic recess, paralleling *Delphinodon dividum*, but differing from both *Prodelphinus malayanus* and *Prodelphinus longirostris* in this respect, for in these living porpoises the *fossa incudis* is shorter and the excavation or groove is continuous with the surface between the fossa for the head of the malleus and the epitympanic orifice of the *Aquaeductus Fallopii.* The narrow *fossa incudis*, which receives the *crus breve* of the incus, extends the full length of the thin ledge which projects inward below the canal for the facial nerve. The anterior half of the *fossa incudis* is shallowly concave and almost horizontal, but posteriorly it terminates in a small deep pit or ovoidal concavity on the anterointernal angle of the posterior process. The anterior border of the projecting ledge for this fossa is free and above it but external to the epitympanic orifice of the *Aquaeductus Fallopii* is a small depression.

The anterior process is robust, almost triangular in cross section, and is obliquely truncated anteriorly. This process bends inward and is slightly twisted. The main articular surface for the accessory ossicle or uncinate process of the tympanic is a broad ovoidal area which occupies the median portion of the ventral surface of the anterior process. This articular surface curves from end to end and slopes toward the *pars cochlearis.* On the adjoining ventral surface of the *pars cochlearis* there is a circular concavity which is supplementary to the main articular surface on the anterior process. When the accessory ossicle is in position the groove between the anterior process and the *pars cochlearis* is completely closed. On the periotic of *Prodelphinus*, however, a narrow groove is left open between the accessory ossicle and the *pars cochlearis.* The concave fossa for the head of the malleus occupies the internal face of the tuberosity or swelling on the basal portion of the anterior process, and also extends inward beyond the external margin of the epitympanic orifice of the *Aquaeductus Fallopii.* The posterior surface of the tuberosity slopes much more obliquely than in *Delphinodon dividum.*

In its general features the cerebral face of this periotic (fig. 7) resembles those of *Delphinodon dividum* and *Prodelphinus.* The conformation of the internal acoustic meatus and associated structures are the chief points of difference. This meatus is broadly pyriform in outline, compressed anteriorly, and terminates in the narrow slitlike channel for the passage of the facial nerve. This channel leads to the entrance to the *Aquaeductus Fallopii* and is partially closed by a slender process which projects from the *pars cochlearis.* It is possible that other periotics will be found which will have the cerebral rim of the internal acoustic meatus complete as in *Delphinodon dividum* and the narrow channel for the facial nerve will remain open as in the latter, with the entrance anterior to the meatus. Within the meatus the *Aquaeductus Fallopii* appears to be compressed from side to side. The elongated orifice of the foramen singulare extends practically the full length of the rim on the low partition between the spiral tract and the entrance to the *Aquaeductus Fallopii.* The *tractus spiralis foraminosus* is well defined with a minute foramen centrale at the anterior end, and the spiral is actually longer than in *Delphinodon dividum.*

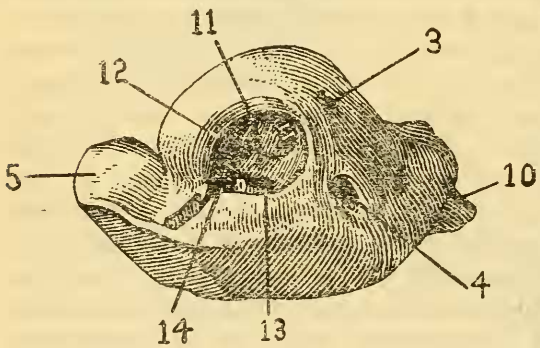


FIG. 7.—INTERNAL OR CEREBRAL VIEW OF LEFT PERIOTIC OF KENTRIODON PERNIX × 2. CAT. NO. 8060, U.S.N.M.

Outside of the internal acoustic meatus and posteroexternally placed is the small orifice of the *Aquaeductus vestibuli*, which opens into a shallow triangular fossa. There is an interval of 3.7 mm. between it and the cerebral orifice of the *Aquaeductus cochleae.* The cerebral orifice of the aqueduct of the cochlea is somewhat larger than that for the vestibule and opens on the posterior face of the *pars cochlearis* at least 2 mm. below the rim of the internal acoustic meatus. On the posterior face of the periotic and above the posterior margin of the stapedial fossa there is a shallow depression which occupies the same area as the slitlike fossa on the periotic of *Delphinodon dividum.*

Measurements of the left periotic (in millimeters)

Breadth of periotic at level of Fenestra ovalis (as measured from external face above groove to internal face of pars cochlearis)	16.9
Greatest length of periotic (tip of anterior process to tip of posterior process)	28.8
Greatest dorsoventral depth of periotic (as measured from most inflated portion of tympanic face of pars cochlearis and groove to most projecting point on cerebral face)	10.5
Distance between Fenestra rotunda and tip of anterior process	16.7
Distance between Fenestra rotunda and tip of posterior process	15.5
Distance between epitympanic orifice of Aquaeductus Fallopii and tip of anterior process	13.4

TYMPANIC

After preparations had been made for the removal of the left tympanic bulla from the mounted specimen for study, it was found that the thin outer lip was badly fractured. The bone was removed as carefully as possible, but unfortunately a few small pieces were missing and no contact could be secured between the sigmoid process, the *processus anterior* of the malleus, and the accessory ossicle or uncinate process with what remained of the thin outer lip. The right tympanic and periotic remain attached to the skull.

On comparing the external surfaces of this tympanic bulla (pl. 1, fig. 3) and that of *Prodelphinus malayanus*, it was interesting to note how differences in proportions modify the general appearance of these bones. It is to be regretted that no comparisons could be made with tympanics of the living porpoise *Sotalia*. According to Van Beneden's figures of the tympanic bulla of *Sotalia guianensis*, the proportions of these bullae appear to be essentially the same when viewed from the external side; the shape of the involucrum is similar and the curvature of the dorsal profile is almost identical. This fossil tympanic bulla is slightly larger than that of *Prodelphinus malayanus*, but the thin outer lip is relatively deeper and the superior border of the lip does not curve inward as abruptly. When viewed from the external side the posterior margin is seen to be less rounded than in *Prodelphinus*, the posterior apophysis is slightly larger, and the tympanic bulla as a whole is relatively deeper. The sigmoid process of this tympanic bulla is not complete, but it is entire on the opposite one; the posterior border and extremity are greatly thickened as in *Prodelphinus malayanus* and the terminal end is twisted at right angles to the basal portion. In front of the sigmoid process there is a distinct crease extending obliquely across the external surface of the thin outer lip from the superior to the inferior margin. The posterior conical apophysis is rather large, but otherwise the relations between this apophysis and the sigmoid process are essentially the same as in *Prodelphinus malayanus*.

The posterior process is borne on a shorter neck than in *Prodelphinus malayanus* and the articular facet is considerably larger. The wide involuted portion (pl. 1, fig. 4) of the tympanic is depressed below the level of the arching thin outer lip and gradually narrows as it approaches the anterior outlet of the Eustachian canal. The surface of the involucrum (pl. 1, fig. 5) is relatively smooth, convex from side to side, and depressed mesially. The involucrum of the tympanic bulla of *Prodelphinus malayanus* is depressed in front of the posterior process.

The thin outer lip of the left tympanic bulla (pl. 1, fig. 5) is sufficiently well preserved to show the size and direction of the anterior outlet of the Eustachian canal. The anterior end of the bulla is slightly produced, forming a narrow lip which projects forward. The superior border of the thin outer lip of the bulla turns and curves inward, forming a narrow shelf. The accessory ossicle or uncinate process of the tympanic is no larger than that of *Prodelphinus malayanus*, measuring 7.8 mm. in length, 6.5 mm. in width, and 3.8 mm. in depth. The dorsal surface of this ossicle is traversed by a shallow mesial groove which curves from end to end. The internal portion of the accessory ossicle is larger, thicker, and more nearly ovoidal in outline than that of *Prodelphinus malayanus*. The dorsal margin of the thin outer lip of the tympanic bulla is fused with the ventral surface of the accessory ossicle along the external margin of this ovoidal internal structure.

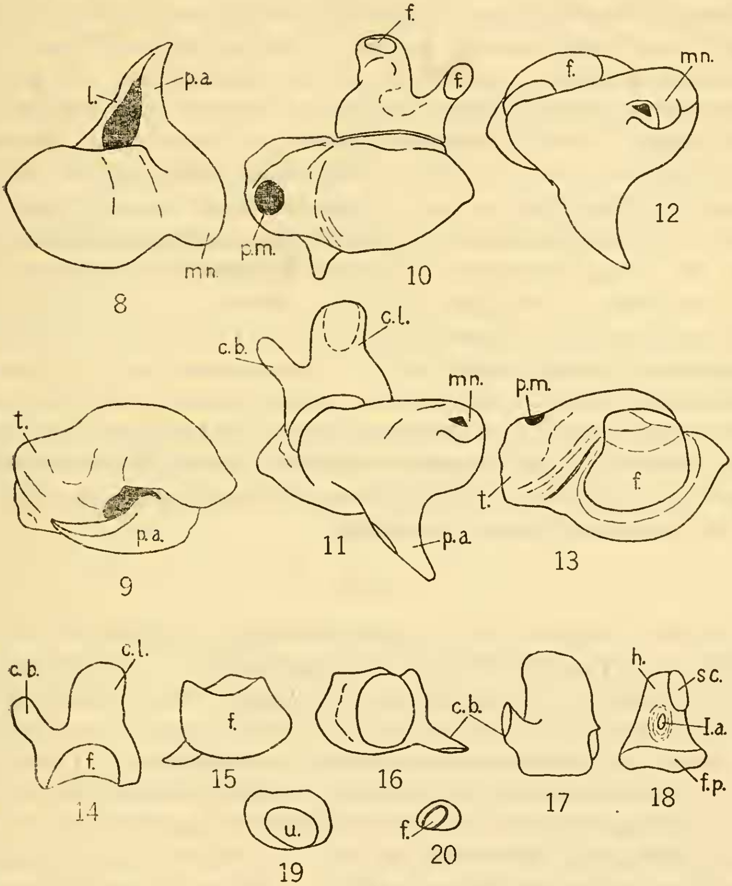
The ventral surface of the tympanic bulla (pl. 1, fig. 2) is slightly depressed mesially. There is a short groove on the anterior end which becomes less distinct as it approaches the mesial depression, but the posterior end is characterized by a large groove which is fully 4 mm. in depth at the posterior margin. When viewed from the ventral face, the inner margin is seen to be biconvex and the outer margin convexo-concave.

Measurements of left tympanic (in millimeters)

Greatest length of bulla	29.7+
Greatest depth of bulla on internal side (ventral face to dorsal face of involucrum	9.9
Greatest depth of bulla on external side (ventral face to tip of posterior apophysis)	16.3+
Greatest width of involucrum	9.4

MALLEUS

The head of the left malleus (fig. 12) is of the same form as in *Prodelphinus malayanus* (Cat. No. 36051, United States National Museum) and the upper facet is larger than the lower. These combined facets articulate with corresponding facets on the incus. A deep groove crosses the head of the malleus (fig. 13) in an oblique direction from the outer to the inner margin, and divides the head



FIGS. 8–20.—LEFT MALLEUS, INCUS, AND STAPES OF KENTRIODON PERNIX. × 5. CAT. NO. 8060. THE SAME ABBREVIATIONS ARE USED ON NUMBERS 8 TO 20 FOR THE FOLLOWING STRUCTURES: *c. b.*, CRUS BREVE; *c. l.*, CRUS LONGUM; *f.*, ARTICULAR FACET; *f. p.*, FOOT PLATE OF STAPES; *h.*, HEAD; *I. a.*, INTERCRURAL APERTURE; *l*, LAMINA; *mn.*, MANUBRIUM; *p. a.*, PROCESSUS ANTERIOR; *P. m.*, PROCESSUS MUSCULARIS; *sc.*, SCAR FOR INSERTION OF STAPEDIUS MUSCLE; *t.*, TUBERCLE; *u.*, UMBO. FIG. 8, EXTERNAL VIEW OF MALLEUS; 9, VENTRAL VIEW OF MALLEUS; 10, DORSOEXTERNAL VIEW OF MALLEUS AND INCUS IN POSITION; 11, VENTROINTERNAL VIEW OF MALLEUS AND INCUS IN POSITION; 12, INTERNAL VIEW OF MALLEUS; 13, DORSAL VIEW OF MALLEUS; 14, VENTRAL VIEW OF INCUS; 15, EXTERNAL VIEW OR BASE OF INCUS; 16, INTERNAL VIEW OR HEAD OF INCUS; 17, POSTERIOR VIEW OF INCUS; 18, POSTERIOR VIEW OF STAPES; 19, VESTIBULAR VIEW OR FOOTPLATE OF STAPES; 20, HEAD OF STAPES

into two surfaces—the tubercle and the combined facets for the incus. The process or tubercle at the anterior end of the head is short and stout, and from it on the internal side arises the manubrium. On the dorsal surface of the tubercle (fig. 10) near the anteroexternal angle and at the end of the groove which traverses the malleus in front of the articular facets is a small circular depressed area for the insertion of the tensor tympani tendon. Below and near the anterointernal angle, the manubrium (fig. 11) is represented by a blunt recurved process, pointing downward and backward, and flattened against the side of the malleus. To a small triangular area near the apex of the manubrium was attached the fleshy process (the "triangular ligament" of authors) of the membrana tympani. Some of the fibres of the fleshy process may be attached in the short narrow groove below the manubrium. The manubrium is slightly more developed than in *Prodelphinus malayanus.* In living whales, according to Ridewood, the extremity of the manubrium is attached by fibrous tissue to the middle of the dorsal surface of the tympanic membrane. The head of the malleus is borne on a slender stalk (fig. 8), the processus anterior (longus, gracilis, and folianus of authors), which becomes narrower as it approaches the outer lip of the tympanic bulla, fusing with the latter in the narrow groove between the sigmoid process and the uncinate process. The malleus, including the anterior tubercle, measures 5.8 mm. in length and 4.2 mm. in width.

INCUS

From the position of the articular surface on the head of the malleus, the incus (fig. 11) lies above and internal to it, with the smallest articular facet on the ventral face of the body. Its articular surface has facets divided by a sharp ridge. Two distinct facets comprise the surfaces by which the incus is fitted to the malleus. The largest (fig. 15) of these two facets is shallowly concave, subcrescentic in outline, and is coextensive with the external face or base of the body of the incus; the smallest facet (fig. 14) is deeply concave and is situated at the base on the ventral side. Curiously enough these two facets are quite similar in appearance and shape to those on the incus of *Prodelphinus malayanus.* The body of the incus is feebly developed, being absorbed by the crus longum. The crus breve (figs. 11, 15, 16, 17) is thin, slightly curved, expanded distally, with an elongate facet on the dorsal surface of the apical portion (fig. 10) which rests in the fossa incudis. The crus longum (figs. 14, 17) is not as thick as in *Prodelphinus*, the ventral surface is less convex, and the facet (fig. 10) for articulation with the head of the stapes is small and is situated on the dorsal face near the apex. From the apex of the crus longum to the base of the body the incus measures 3.2 mm. and the greatest diameter of the base is 2.8 mm.

STAPES

The stapes (fig. 18) is of the same form as in *Prodelphinus*. The intercrural aperture is small and connects the relatively large concavities on the opposite sides. A slight side to side movement is permitted when the stapes is in position, but the footplate is closely fitted to the free margin of the fenestra ovalis. The stapes bears on its footplate (fig. 19) a distinct umbo or large oval concavity on the vestibular face. There is a well-defined scar (fig. 18) on the postero-internal angle below the head which seems to mark the attachment of the stapedius muscle, and this portion of the stapes projects slightly. The facet (fig. 20) which marks the point of contact with the corresponding facet on the head of the crus longum of the incus is small and is placed obliquely on the head of the stapes.

MANDIBLES

Minor differences between the mandibles of this fossil porpoise and those of *Sotalia tucuxi* show that too much weight should not be assigned to the general shape for purposes of identification. The mandibles (pl. 4) of this fossil porpoise resemble those of *Sotalia tucuxi* so closely that with the exception of certain points hereinafter mentioned a description of one might apply equally well to the other. These mandibles differ from those of *Sotalia tucuxi* in that the symphysis is longer and from those of *Delphinodon dividum* in that the posterior margin of the coronoid process above the condyle is more nearly vertical and the number of alveoli is greater. The right mandible has been freed from the matrix, but the left is partially embedded. The mandible is rather long as compared to the skull and the ramus is slightly deeper than that of *Sotalia tucuxi*. The ramus is slenderest at the posterior end of the symphysis and the tooth row occupies about 65 per cent of its total length. The symphysis is longer than in *Sotalia tucuxi*, being almost one-third of the length of the mandible, while in the latter it is less than one-sixth. The rami are firmly ankylosed throughout the symphysis and curve upward to the extremity. On the outer face of the mandible and in position corresponding to the middle of the tooth row are five foramina, from each of which a short canal leads forward. The proximal foramen is placed nearest to the superior margin and the distal foramen nearest to the inferior margin; the first-mentioned foramen opens at the level of the fifteenth tooth, counting forward from the last, and the last-mentioned foramen opens at the level of the posterior end of the symphysis. There is a stitchlike or interrupted stria which commences on the inferior margin in front of the angle and gradually rises on the outer face as it passes forward until it merges into the groove leading forward from the foramen at the level of the posterior end of the symphysis.

The conformation of the proximal end of the right mandible is similar to that of *Sotalia tucuxi*, except that the angle is prolonged farther backward and the posterior margin of the ramus above the angle is more strongly curved. The coronoid region is not especially elevated, the distance between the apex of the coronoid process and the inferior margin of the angle amounting to less than one-fourth of the total length of the mandible. The superior margin of the mandible slopes from the coronoid process to the middle of the tooth row, while the inferior margin is convex behind the end of the tooth row. The external face of the proximal end of the mandible is convex, except that the superior border of the coronoid process is bent outward as in *Sotalia tucuxi*. Although the right mandible is distorted from crushing, the angle appears to have extended backward nearly to the level of the condyle. The condyle is elliptical in outline, with the long axis oblique.

Back of the tooth row and on the internal surface of the ramus there is the usual orifice for the large dental canal. Beyond this orifice the ramus consists mainly of the thin outer shell, with the addition of shelving strips which merge into the upper and lower borders.

Measurements of the right mandible (in millimeters)

	Cat. No. 8060
Greatest length of right mandible (condyle to tip)	262
Greatest breadth of combined mandibles at extremity	10
Greatest depth of combined mandibles at extremity	10
Greatest depth of right mandible at proximal end of symphysis	15.8
Greatest depth of right mandible at level of proximal alveolus	31
Greatest length of symphysis	85
Distance from proximal alveolus to distal alveolus	161+
Depth of condyle of right mandible	18

TEETH

With the exception of the distal ones, practically all of the teeth are in position on the left side of the rostrum and on the left mandible. Behind the greatly enlarged anterior tooth at least five teeth are missing near the extremity on the right side of the rostrum and more than half of the teeth are missing on the right mandible. In addition, seven detached teeth have been preserved. The dental formula was originally about $\frac{40—40}{38—38}$.

The teeth (pl. 4) are small, very close together, and have slender crowns, the apices of which are recurved. These teeth are quite unlike those that have been described previously from the Calvert formation of Maryland. With the possible exception of *Platanista croatica* [12] and *Heterodelphis leiodontus* [13] they do not resemble any of the teeth described from European formations.

These teeth differ from those of *Delphinodon dividum* [14] in so many respects that there is hardly any possibility of confusing them. To emphasize the differences existing between the teeth of these two small dolphins their main characteristics may be summarized as follows: In *Delphinodon dividum* the crowns of the teeth are recurved, with a carina on the anterior and posterior cutting edges, and the enamel is rugose; the posterior teeth have one or more accessory cusps; the roots are slender, elongated, somewhat gibbous below the base of the crown, curved backward at the extremity, and have a large dentinal canal. The largest teeth have a length of 29 mm. and a maximum diameter of 5 mm.; the smallest teeth are 20 mm. long and have a maximum diameter of 4 mm.; the teeth are more or less crowded in the upper and lower jaws. In comparison to those of *Delphinodon dividum* the majority of the teeth of this porpoise are shorter, more slender, and have less swollen roots; the crowns are recurved, but the enamel is relatively smooth; neither accessory cusps nor carinae are present on any of the teeth; one of the largest teeth has a length of 38.3 mm. and a maximum diameter of 3.9 mm.; the smallest teeth are 13 mm. long and have a maximum diameter of 2.8 mm.; the teeth in the upper and lower jaws are separated by intervals slightly less than the maximum diameter of the opposing teeth. The anteriormost tooth on each side is greatly elongated, inserted in the extremity of the premaxilla, and projects forward and slightly downward. The crown of this large tooth measures 11.5 mm. in length and 3.5 mm. in diameter at the base; it tapers gradually and the apex bends downward slightly. The ratio of the enamel crown to the whole tooth varies considerably, being equivalent to less than one-third of the total length on the largest teeth and about one-half on the smallest. Near the anterior end of the series the crowns (pl. 8, figs. 2, 5, 7) are more noticeably compressed in an anteroposterior direction at the base, their apices are more attenuated, and the inward curve is less pronounced than on the posterior teeth. The crowns of the teeth (pl. 8, fig. 3) from near the posterior end of the middle portion of the series are relatively short, robust, and their apices are acute and curve strongly

[12] Gorjanović Kramberger, D., De fossilibus Cetaceis Croatiae et Carneoliae. Rad jugoslavenske akademije znanosti i umjetnosti, Zagreb, vol. 111, pl. 1, figs. 5, 5*a*, 6. 1892.

[13] Papp, C. von, Heterodelphis leiodontus nova forma aus den Miocenen Schichten des Comitates Sopron in Ungarn. Mitteil. Jahrbuche Königl. Ungar. Geol. Anstalt, Budapest, vol. 14, Heft 2, text fig. 8, pl. 5, 1905.

[14] True, F. W., Description of a new fossil porpoise of the genus *Delphinodon* from the Miocene formation of Maryland. Journ. Acad. Sci. Philadelphia, ser. 2, vol. 15, pp. 171–174, pl. 19, figs. 1–2; pl. 26. December 9, 1912.

inward. The apex of the crown is most strongly incurved on teeth at the proximal end of the series and less so distally. None of these teeth exhibit any trace of accessory cusps or tubercles. The enamel on the crown is perfectly smooth; the basal margin of the enamel crown is irregularly curved, but no cingulum is developed and the enamel passes into the cementum of the root very gradually, without any perceptible increase or decrease in the diameter of the neck. The penultimate maxillary and mandibular teeth are present on both sides. With the possible exception of the very long teeth (pl 8, fig. 1), the extremities of the roots of all the teeth curve backward. In some instances there is a slight side to side enlargement of the root below the crown. On such teeth both the upper part of the root and the base of the crown are flattened anteriorly and posteriorly. The mandibular teeth are similar to the maxillary in form and size. Unfortunately the anteriormost mandibular teeth are missing from both jaws, but the presence of an additional detached tooth (pl. 8, fig. 1) indicates that the terminal tooth in each mandible was elongated like its mate in the corresponding premaxilla.

Measurements of the teeth (in millimeters)

	Pl. 8, fig. 1	Pl. 8, fig. 2	Pl. 8, fig. 3	Pl. 8, fig. 4	Pl. 8, fig. 5	Pl. 8, fig. 6	Pl. 8, fig. 7
Total length	38. 3+	16. 8	16. 5	15	14	13. 5+	13. 1
Length of crown	11. 5	7. 9	6. 1	6. 4	6. 8	7. 4	6. 3
Greatest diameter of crown at base	3. 5	2. 9	2. 9	2. 9	2. 8	3	2. 7
Greatest diameter of root	3. 9	3. 2	3	3. 2	2. 9	3. 1	2. 8
Least diameter of extremity of root	0. 8	1	0. 9	0. 8	0. 8	x	0. 7

HYOID BONE

Only one of the hyoid bones (pl. 1, fig. 1) is preserved and, judging from its size and other peculiarities, it is the right thyrohyal. This bone is embedded in the matrix behind the left exoccipital and its base is in contact with the transverse process of the atlas. In *Delphinodon dividum*, the lateral winglike thyrohyals are free and are not ankylosed at the base with the basihyal. This may or may not be due to immaturity.

This right thyrohyal is at least 49 mm. long, 8.5 mm. wide at the constriction near the base, and 11.5 mm. wide at the most expanded portion. The extremity is buried in the matrix and the proximal end or base is rugose for cartilaginous attachment to the basihyal. This bone is thickest at the base and tapers to the distal end; the posterior margin is nearly straight, but the anterior is slightly convex. It differs from the thyrohyal of *Delphinodon divi-*

dum in its smaller size and also in the curvature of the anterior and posterior margins, but otherwise the resemblance is rather close.

CERVICAL VERTEBRAE

No ankylosis between individual vertebrae (pl. 14) can be observed in this cervical series, but the centra are crushed against one another. They were not removed from the matrix for study, although direct comparisons were made between them and those of *Delphinodon dividum*, and all of their essential characteristics were determined in this manner. Seven cervical vertebrae comprise this series. The chief peculiarities observable in the cervical series may be enumerated as follows: Atlas of small size, its maximum length being about one-half of its height, with low spine, strong inferior and vestigial bladelike superior transverse processes, and well-developed hyapophysial process; axis with long thick spine, strong inferior transverse processes and small odontoid; neural spines of third to seventh cervicals vestigial; inferior transverse processes of third to fifth cervicals slender, directed obliquely backward, and those of the third are more than twice as long as those of the fifth; inferior transverse processes of sixth cervical relatively large, directed nearly vertically downward; inferior transverse processes of seventh cervical are vestigial; axis and third to seventh cervicals, inclusive, exhibit a longitudinal carina on inferior surface of centrum; foramen at base of superior transverse process on sixth cervical much larger than on any of the preceding; zygapophyses of third to sixth cervicals very similar in size and shape, while those of seventh are much larger; as regards height the centra of the third to seventh cervicals are all about the same; epiphyses of all these vertebrae are very thin.

Atlas.—The atlas differs from that of *Delphinodon dividum* not only in its smaller size, but also in relative height. Another atlas (pl. 12, figs. 3, 4) collected in zone 10 of the Calvert Cliffs has been referred to this species. In general form, as viewed from in front, these two atlases resemble the same vertebra in *Sotalia.* Both of these fossil atlases are relatively long anteroposteriorly, their maximum lengths being about one-half of their height. The upper transverse processes are merely blade-like crests arising along the posterosuperior margin as in *Delphinodon dividum*, but the lower processes are relatively large. On the second atlas (pl. 12, fig. 3) the facets for articulation with the occipital condyles are concave, broader above than below, and are separated inferiorly by a rather wide interval (11.2 mm.). The neural arch is very little elevated and is narrow anteroposteriorly (11.9 mm.) near the spine. It is pierced on each side by a vertebrarterial canal and bears a low blunt spine. The lower transverse processes are short, thickened, and project obliquely downward and backward. The posterior articular facets (pl. 12, fig. 4) for the axis are subovoidal with convexo-concave surfaces and are set off from the posterior face of the centrum by distinct margins. The hyapophysial process is short, thick, and emarginate. On the upper surface of the hyapophysial process and at the base of the pyriform neural canal there is a large heart-shaped facet for articulation with the odontoid process of the axis.

Axis.—In comparison to the axis of *Delphinodon dividum*, this vertebra is considerably smaller, measuring 57.7 mm. in height and 62.5 mm. between the extremities of the inferior transverse processes, and its greatest thickness anteroposteriorly is more than one-fourth of its breadth, or 16.7 mm. The neural spine is stout, thick at the base, and is inclined backward; the posterior face of the spine is grooved and a low carina is developed on the anterior face. It differs from *D. dividum* in that the neural spine (pl. 5, fig. 1) is proportionately longer; the inferior transverse processes (pl. 14, No. 19) are also longer and are directed more obliquely backward. In *Sotalia* the neural spine of the coossified axis and atlas is excessively enlarged and is directed more backward than upward, projecting above at least four of the succeeding cervicals. The shape of the neural canal and the proportions of the anterior articular facets can not be determined at present. It was possible to determine, however, that the centrum is not as high as in *D. dividum* and the neural canal is relatively shallower. The postzygapophyses have nearly horizontal articular surfaces and are situated nearly as high up as the top of the neural canal. The odontoid process is very similar in shape and proportions to that of *D. dividum*. The transverse processes are directed obliquely backward and outward and are much larger and longer than the corresponding processes of the atlas. They are deep vertically, rather thin anteroposteriorly, and the extremity is obliquely truncated in two directions. There is a longitudinal carina on the interior face of the axis and corresponding depressions on each side.

Third cervical.—The centrum of this cervical is not visible as it has been forced out of its normal position in the series into the neural canal of the axis. The zygapophyses and a portion of the neural arch are all that are exposed on the right side. The position of the remainder was determined by probing. The superior transverse process is slender, with a small elliptical vertebrarterial canal at the base. The inferior transverse process (pl. 14, no. 20) on the left side is slender and more than twice as long as that on the fifth cervical.

Fourth cervical.—The centrum of the fourth cervical (pl. 14, no. 21) is thin, the neural arch is rather broad at the base, and the spine is very low. The inferior processes are slender and are shorter than those of the third cervical. The superior transverse processes are thin, projecting obliquely downward and outward, and enclosing a small vertebrarterial canal.

Fifth cervical.—As regards thickness, the centra of the fourth and fifth cervicals are about equal. The neural arches are slightly thicker than those of the fourth and are inclined very slightly backward, but the zygapophyses are similar to the preceding. The inferior transverse processes (pl. 14, no. 22) are considerably shorter than those of the fourth and are also thicker. Most of the superior transverse process on the right side is missing, but enough remains to show that the vertebrarterial canal is much larger than any of the preceding.

Sixth cervical.—The centrum is slightly thicker than the preceding. Probably the most characteristic feature of this cervical (pl. 14, no. 23) is the direction of the inferior transverse processes. These processes are similar in proportions to those of *Delphinodon dividum*, but are directed almost straight downward, while in *D. dividum* they are directed as much outward as downward. The distance between the extremities of the inferior transverse processes is 35.5 mm. (outside measurement). The neurapophyses are essentially vertical. The superior transverse processes are bladelike plates which are inclined forward. The neural spine is very short.

Seventh cervical.—In contrast to the preceding cervical, the thin blade-like superior transverse processes are directed forward and the inferior ones are vestigial. The centrum (pl. 14, no. 24) also is slightly thicker than the sixth, and the neurapophyses curve upward and forward. There is an articular facet for the capitulum of the first rib on the posterosuperior angle of the centrum. The greatest anteroposterior diameter (14.1 mm.) of the combined zygapophyses is considerably greater than that of the preceding vertebra (10 mm.). Both epiphyses are missing.

Measurements of the cervical vertebrae (in millimeters)

	Atlas	Axis	3rd	4th	5th	6th	7th
Greatest depth (vertically) of vertebra (tip of neural spine to inferior face of centrum)	37. 6	57. 7	x	33+	33. 2	33	34. 3
Length of centrum	15	16. 7	x	6. 1	6. 2	8	[1] 5
Distance across vertebra between tips of transverse processes (parapophyses)	60	62. 5	x	42+	41+	35. 5	x
Distance between tip of right postzygapophysis and tip of right prezygapophysis	x	x	10	11. 2	10. 2	10	14. 1
Minimum anteroposterior diameter of neurapophysis	x	x	2. 6	2. 8	3	2. 2	x

[1] Both epiphyses missing.

DORSAL VERTEBRAE

It is fortunate that this vertebral column (pl. 1, fig. 1) is intact from the atlas to the fifth lumbar. Because of this fact one can state definitely that the dorsal series consists of not more than 10 vertebrae. With the exception of the extremities of the neural spines and the right transverse processes of the ninth and tenth dorsals, all of these vertebrae are practically complete. The epiphyses of some are loose and a few are missing entirely. The neural arches of all of the dorsal vertebrae are crushed in one direction or another and this must be taken into consideration whenever the measurements given on page 41 are utilized for purposes of comparison. As regards the posterior dorsals, the centra are slenderer and the neural spines relatively wider than those of *Delphinodon dividum*. As compared to those of *Sotalia guianensis*,[15] they differ chiefly in the relative lengths of the centra of the corresponding vertebrae and in the proportions of the neural spines. The posterior dorsal vertebrae of this fossil porpoise differ noticeably from the corresponding vertebrae of many living delphinoids in that the neural spines in proportion to the height of the vertebrae are short and wide, instead of being elongated.

The relation between the length and width of the centrum, the shape of the neural spine, the width of the interval between the prezyapophysial facets, as well as the peculiarities of the diapophysis, including the position of the facet for the tuberculum, will serve as a guide for determining the position of any dorsal in the series. The centra increase in length from the first to the last, the centrum of the tenth dorsal being more than three times as long as the first. The epiphyses of all the dorsals are relatively thin. There is no transitional dorsal with paired facets for articulation with the corresponding rib. Slender neural spines with recurved extremities are the chief peculiarities of the first three dorsals; the neural spines of the remaining dorsals are wider anteroposteriorly and have squarely truncated extremities. There is a progressive decrease in the width of the interval separating the prezygapophysial facets from the anterior to the posterior dorsal. These facets are nearly horizontal on the first seven dorsals, while those of the last three slope obliquely downward and inward. On the first four dorsals the diapophyses are elongated and the facet for articulation with the tuberculum of the rib is situated anterior to the level of the epiphysis, but on the eighth it is entirely behind the level of the epiphysis. The facets for the tubercula increase in length from the first to the eighth dorsals, but decrease in width. On each side of the centrum of the first to the sixth dorsals, inclusive, below the level of the base of the neural

[15] Van Beneden, P. J., and P. Gervais, Ostéographie des Cétacés vivants et fossiles, Paris, Atlas, pl. 41, fig. 1. 1880.

arches and at the posterosuperior angle, there is a well-defined facet for the accommodation of the head of the following rib. Anteriorly the diapophyses arise high up on the neural arch and gradually shift their position to a lower level from the first to the seventh dorsal, but on the eighth the shift is more noticeable since each process arises from the side of the neural arch about midway between the centrum and the top of the neural canal. The postzygapophysial facets become progressively shorter toward the posterior end of the dorsal series and disappear entirely on the first lumbar.

First dorsal.—The anterior dorsal of this porpoise exhibits the structural pecularities which characterize the first dorsals of most living delphinoids. The centrum is nearly three times as wide as long and the usual facet for the capitulum of the second rib is situated at the base of the neural arch on the posterosuperior lateral border of the centrum. The neural spine is especially slender and is curved from base to apex. The neural arch is low, stout, and narrow anteroposteriorly, with a lateral diapophysis on each side which bears a large articular facet for the tuberculum of the first rib. The articular facet which occupies the extremity of this process slopes downward and inward. The neck of the diapophysis is constricted dorsoventrally between the facet and the neural arch. The postzygapophysial facets are large, elongate, and slope obliquely inward. Both epiphyses are missing.

Second dorsal.—Compared with the first dorsal, the centrum is longer, the neural spine is higher, and the articular facet for the tuberculum of the third rib is slightly smaller. The neural spine is slender, but less strongly curved than that of the first dorsal. There is a medium-sized facet for the capitulum of the third rib at the posterior end of the centrum in the usual position. The neural arch is of approximately the same proportions as on the preceding dorsal. The posterior epiphysis is missing and the anterior one is separated from the centrum.

Third dorsal.—The centrum of this dorsal is almost twice as long as that of the first. The neural spine tapers to the extremity and is the least curved of the three anterior dorsals. The diapophyses have shorter necks and the facets for the capitula of the fourth ribs are considerably larger than on the preceding vertebra. The posterior epiphysis is attached to the centrum, but the anterior epiphysis is loose and projects laterally beyond it on the left side.

Fourth dorsal.—The centrum is more than one-half as long as broad. Both epiphyses are attached to the centrum. This vertebra is further characterized by shorter diapophyses and the neural spine is of approximately the same width throughout. Compared with the same vertebra of *Delphinodon dividum* the centrum is proportionately larger and broader, the neural canal is lower, and the diapophyses are shorter.

Fifth dorsal.—In general appearance this vertebra is very similar to the fourth. The centrum (pl. 14, no. 29) is longer than that of the fourth and is more noticeably constricted from side to side near the middle. Both epiphyses are attached to the centrum. The neurapophyses are more highly arched than on the fourth. The metapophyses are broader than on the preceding dorsals and the diapophyses are shorter. The neural spine is similar in outline to that on the fourth dorsal. Compared with the same vertebra of *Delphinodon dividum*, the neural arches and neural spine are relatively wider anteroposteriorly.

Sixth dorsal.—The centrum is almost as long as broad and the neural spine is somewhat wider anteroposteriorly. The centrum is so strongly constricted that an indistinct ventral carina is developed. Both epiphyses are attached to the centrum. The mesial dorsoventral constriction of the diapophyses has disappeared. On the first six dorsals there are distinct facets on the posterosuperior lateral borders of the centra for the capitula of the following ribs, but they are not developed on the seventh and succeeding dorsals. This indicates that there were not more than seven pairs of double headed ribs.

Seventh dorsal.—This vertebra differs very little from the sixth. The centrum (pl. 14, no. 31) is slightly longer than broad, distinctly constricted near the middle, and the tips of the metapophyses are directed upward. The facet on the diapophysis for the tuberculum is subtriangular in outline and the whole process projects at a slightly lower level than on the preceding dorsal. The neural spine is slightly constricted below the extremity. On the first seven dorsals the bases of the neural arches extend practically the full length of the centrum, but on the eighth, ninth, and tenth dorsals they have receded from the posterior epiphysis. Both epiphyses are loose and project laterally beyond the centrum on the left side.

Eighth dorsal.—There is no transitional dorsal with closely approximated facets for the tuberculum and capitulum of the corresponding rib on the side of the neural arch as in *Eurhinodelphis* and many of the living delphinoids. On the eighth dorsal (pl. 14, no. 32) of this fossil porpoise, however, there is a single facet which is placed on the extremity of a short diapophysis. The distance from the inside margin of the neural arch to the tip of the diapophysis is 16.5 mm. The diapophyses project laterally from the neural arches at a considerably lower level than on the seventh dorsal. There is a noticeable increase in the length of the centrum. Both epiphyses are attached to it. The neural spine is wider anteroposteriorly than on the seventh dorsal, and the same holds true for the neural arches. The anterior margin of the neural spine is more strongly curved than the posterior margin.

Ninth dorsal.—This dorsal (pl. 9, fig. 2) is characterized by a short transverse process (parapophysis) with a wide facet on the extremity for a single-headed rib. The centrum is elongated and constricted from side to side mesially. The anterior epiphysis is loose and projects laterally beyond it on the left side. The metapophyses are large and project obliquely upward.

Tenth dorsal.—The centrum (pl. 9, fig. 3) is longer than broad and the neural arch is slightly wider than on the ninth vertebra. There is a large facet for a single-headed rib on the extremity of the long parapophysis which projects laterally from middle of the centrum. There are some points about the restored right parapophysis which are incorrect. The parapophysis on the left side is complete and the description is based upon this process. The neural spines of the ninth and tenth dorsals are similar in shape and proportions. The metapophyses are large and the postzygapophyses are very much reduced in size. The posterior epiphysis is missing, but the anterior epiphysis is attached to the centrum.

Measurements of the dorsal vertebrae (in millimeters)

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Greatest depth (vertically) of vertebra (tip of neural spine to inferior face of centrum)	52. 3	58	61	61. 2	63. 7	67	67. 2	70	75	73+
Height of anterior face of centrum	x	x	17. 8	18	x	x	19	19. 5	x	x
Breadth centrum posteriorly across facets for tubercula	31	29. 2	29. 5	28. 8	26. 2	x	22. 8	22. 7	x	27. 1
Length of centrum	[2] 8. 9	[2] 11	[1] 15. 8	18. 7	19. 8	[1] 21. 8	23	26. 9	[1] 30. 5	[1] 28. 4
Distance across vertebra between tips of diapophyses	59	x	54	51. 5	x	x	46. 9	51. 7	x	x
Distance across vertebra between tips of transverse processes (parapophyses)	x	x	x	x	x	x	x	x	64	[3] 72
Minimum length of neurapophysis	x	5. 4	6. 5	x	x	x	8	9. 5	x	15
Vertical height of neural spine (distance between superior margin of neural canal and tip of spine)	21+	27+	32+	33+	34+	35+	37+	39+	42+	6 44+
Minimum anteroposterior diameter of the neural spine	7	8. 5	8. 5	10. 5	12. 5	14. 7	13. 7	16. 4	18. 1	18. 5

[1] One epiphysis missing. [2] Both epiphyses missing. [3] Estimated, right parapophysis destroyed.

LUMBAR VERTEBRAE

All of the lumbar vertebrae are incomplete and none retains the transverse process on the right side. Of the anterior lumbars there are three that are more or less complete and two others are represented by the left transverse process; these five lumbar vertebrae represent a consecutive series. All of the intervening lumbars between these and the two that constitute the end of the series are lost. The neural spine and right transverse process are not preserved on the last lumbar and with the exception of the left transverse process all of the second from the last is missing. When complete the lumbar series probably consisted of nine or ten vertebrae. The centra are all longer than broad and progressively increase in length from the anterior one backward. Judging from the centra of the two anterior lumbars and the last lumbar, all of them have a more or less distinct median inferior carina. The transverse processes are as long as the neural spines, very thin, and taper to the distal end which is expanded anteroposteriorly. The transverse processes of the anterior lumbars are inclined forward and those of the posterior ones backward. The neural arches and the neural spines are preserved on the three anterior lumbars. The neural spines are nearly vertical, relatively broad anteroposteriorly, with their expanded extremities rather squarely truncated. The neural arches of the anterior lumbars are vertical, but those of the posterior lumbars are inclined forward. The minimum anteroposterior diameter of the neural arch is slightly less than one-half the length of the centrum, but each neurapophysis is slightly wider at the base. The neural spine is broader anteroposteriorly than the neural arch. The thin lamina-like metapophyses are directed obliquely upward and forward; their superior margins are convex and their inferior margins are angulate. There are no distinct anterior and posterior zygapophyses. The epiphyses of the posterior lumbar are very slightly if at all thicker than either of those on the anterior lumbar.

The lumbars of this fossil porpoise, as compared with those of *Delphinodon dividum*, have more elongated centra, broader neural spines, larger metapophyses, and the transverse processes have expanded extremities in contrast to the slender type of the latter.

First lumbar.—The distal extremity of the neural spine and the major portion of the right transverse process are missing (pl. 9, fig. 4), but only the tip of the right metapophysis is damaged. The centrum is slender, constricted mesially, and exhibits a faint median inferior carina. Both epiphyses are attached to the centrum. The left transverse process is slender, slightly expanded at the extremity, but with the anteroexternal angle obliquely truncated and rounded off. The superior margin of the large metapophysis turns sharply at the base and forms a distinct angle. The neural arch is not crushed and is not quite as broad as the minimum anteroposterior diameter of the neural spine. In spite of the fact that the neural spine is broken transversely below the middle, at the base, and at the extremity, it is otherwise fairly well preserved.

Second lumbar.—As compared with the first lumbar, the centrum (pl. 9, fig. 5) is slightly longer and wider, the transverse processes are longer, and the neural canal is narrower. All of the right transverse process, the distal extremity of the neural spine, and both epiphyses are missing. The right metapophysis is complete and differs from that on the preceding in that no angle is formed at the base by the superior margin, while the inferior is distinctly angulate. The median inferior carina is more distinct than on the first lumbar. The neural spine is broken transversely near the middle and the extremity is slightly damaged. The left transverse process is more slender, slightly longer, but with the extremity similar to that on the preceding lumbar.

Third lumbar.—The major portion of the centrum (pl. 9, fig. 6), all of the right transverse process, the posterior epiphysis, and the neurapophysis on the right side are missing. The right metapophysis is damaged, but seems to agree with that on the second lumbar. The left transverse process is slightly longer than that on the preceding lumbar and the anteroexternal angle is less obliquely truncated. The neural spine seems to be complete. It is squarely truncated at the extremity and is more noticeably constricted anteroposteriorly than that on the second lumbar.

Fourth lumbar.—Of this lumbar the left transverse process alone remains and it is shorter than on the third, less noticeably constricted anteroposteriorly near the base, more expanded at the extremity, and the anteroexternal angle is less obliquely truncated.

Fifth lumbar.—With the exception of the left transverse process all of this lumbar is missing. This process is slightly shorter than on the fourth lumbar, wider anteroposteriorly at the narrowest part, more expanded distally, and the extremity is truncated nearly at right angles to its main axis.

Ninth lumbar.—The distal portion of the left transverse process is all that remains of this lumbar (pl. 11, fig. 1) and it lacks the anteroexternal angle. It may not be correct as restored.

Tenth lumbar.—Of this lumbar (pl. 10, fig. 1), the neural spine, the neural arches, the anterior epiphysis, and the right transverse process are missing. In comparison to the fifth lumbar, the left transverse process (pl. 11, fig. 2) is somewhat shortened, but the anteroexternal angle is missing. It now appears that the transverse processes are incorrect as restored, because this angle should be less prominent to correspond with the progressive increase of the posteroexternal angle on the anterior caudals. The centrum is longer and broader than that of the first lumbar and is constricted behind the neural arches. The right transverse process and neural spine have been restored.

Measurements of the lumbar vertebrae (in millimeters)

	1st	2nd	3rd	4th	5th	10th
Greatest depth (vertically) of vertebra (tip of neural spine to inferior face of centrum)	79+	80+	x	x	x	x
Height of anterior face of centrum	21	21	x	x	x	x
Breadth of anterior face of centrum	24. 5	26	x	x	x	31
Height of posterior face of centrum	x	22. 5	x	x	x	26
Breadth of posterior face of centrum	25. 5	30. 2	x	x	x	x
Length of centrum	33. 4	36	x	x	x	[2] 36. 5
Distance from inferior carina on centrum to tip of left transverse process	54	60	[1] 70	x	x	61
Maximum width of extremity of left transverse process	18. 5	20	22. 8	24	27	x
Distance between tip of right postzygapophysis and tip of right prezygapophysis	40+	45	x	x	x	x
Minimum anteroposterior diameter of neurapophysis	16. 5	16. 5	18	x	x	x
Anteroposterior length of neural spine in a horizontal line immediately above the zygapophyses	33. 5	36	35. 5	x	x	x
Vertical height of neural spine (distance between superior margin of neural canal and tip of spine)	48+	47+	51. 5	x	x	x
Minimum anteroposterior diameter of neural spine	19. 5	19	18	x	x	x

[1] Estimated. [2] Anterior epiphysis missing.

CAUDAL VERTEBRAE

The caudal series is likewise incomplete and the position (pl. 1, fig. 1) of those that are preserved shows that they were torn apart before they were completely covered by sediments. Behind the posterior lumbar are the first, second, and third caudals, and the anterior epiphysis of the fourth. Two others which appear to be the sixth and seventh caudals are isolated from the rest. Behind them there appears to be another hiatus, for there are five consecutive vertebrae from near the middle of the series which appear to be the tenth, eleventh, twelfth, thirteenth, and fourteenth caudals. In addition to the above, there is one small terminal caudal.

In enumerating the differences between the caudal series of this fossil porpoise and that of *Sotalia guianensis*, the relative anteroposterior diameters of the neural arches and the position of the dorsal orifice of the lateral vertebrarterial canal should not be overlooked.

The three anterior caudals of this fossil porpoise do not have their transverse processes pierced at the base by a foramen. In *Sotalia* the first and second caudals have transverse processes without perforations and on those near the middle of the series the dorsal orifice of the lateral vertebrarterial canal is nearer to the posterior epiphysis than in *pernix*.

On the anterior caudals the neural canals are narrow and high and they progressively decrease in height up to the fourteenth, beyond which they disappear entirely. The neural arches increase in diameter anteroposteriorly from the first to the fourteenth and on the last-mentioned caudal extend nearly the full length of the centrum. In correlation with the progressive shortening of the neural arches toward the end of the series the metapophyses drop down to a lower level on each succeeding vertebra, those on the first caudal being elevated at least 30 mm. above the top of the centrum, while those on the fourteenth are not more than 3.5 mm. above the centrum. The transverse processes decrease in size from the first to the eleventh and are vestigial on the twelfth. On four of the caudals near the middle of the series (11th to 14th) there are a pair of longitudinal platelike descending processes upon the extremities of which are situated the facets for the chevron bones.

First caudal.—All of this caudal (pl. 11, fig. 3) is well preserved save for the distal portion of the neural spine. The centrum (pl. 10, fig. 2) is approximately equal in length to the last lumbar and is constricted behind the neural arches, with two small articular facets on the ventral surface at the posterior end for the corresponding chevron. The metapophyses are damaged, but their superior margins were originally at least 30 mm. above the top of the centrum. The neural arches are inclined forward, the minimum anteroposterior diameter being less than one-half the length of the centrum. The neural canal is narrow and both neural arches are cracked near the middle. The epiphyses are thin. The transverse processes are short, constricted anteroposteriorly near the base and expanded at their distal extremities. The posteroexternal angles are quite prominent.

Second caudal.—The entire neural spine, both metapophyses, the major portion of the neural arches, the anterior epiphysis, and the extremity of the right transverse process are missing. The centrum (pl. 10, fig. 3) is approximately equal in length to that of the first caudal. The transverse processes (pl. 11, fig. 4) are shorter than those on the preceding caudal, more expanded anteroposteriorly at the extremity, and the posteroexternal angle is prolonged backward. The paired facets for the chevron on the inferior surface of the centrum at the posterior end are relatively large. The neural canal is not more than 13 mm. in height posteriorly.

Third caudal.—It (pl. 10, fig. 4) is complete with the exception of the distal end of the neural spine and the extremities of the metapophyses. The centrum is similar in proportions to the first and second lumbars, but is shorter. The neural canal is not over 10 mm. in height posteriorly. The posterior margin of the neural spine does not quite overhang the base of the neural arch. The minimum anteroposterior diameter (17.9 mm.) of the left transverse process is about two-thirds the diameter (29.8 mm.) at the extremity. The posteroexternal angles of the transverse processes (pl. 11, fig. 5) are very prominent. The tip of the left and most of the right metapophyses are destroyed; their superior margins were not over 28 mm. above the top of the centrum.

Fourth caudal.—Of this caudal (pl. 10, fig. 5) the anterior epiphysis alone is preserved. The major portion of this ephiphysis is hidden by the matrix. It measures 3.4 mm. in thickness. Most of the ridges for attachment to the centrum radiate from the center.

Sixth caudal.—With the exception of the anterior epiphysis, all parts of this vertebra (pl. 12, fig. 1) are present. Judging from the length of the centrum and other peculiarities, this seems to be the sixth in the series. The posterior facets for the chevrons are placed obliquely on the posterior faces of the large descending processes, while the anterior facets are narrower and barely discernible. The left transverse process is strongly constricted at the base, measuring 16.8 mm. in width, the extremity is expanded, and the distance between the canal at the base and the anteroexternal angle is 28.4 mm. The metapophyses are large processes which have a lateral carina and they project forward beyond the level of the anterior epiphysis; their superior margins are at least 25.5 mm. above the top of the centrum. The neural arches are relatively broad in comparison to the length of the centrum and are inclined forward. The neural spine is wider than the neural arch, short in proportion to the size of the centrum, but longer than the transverse process, and with the extremity squarely truncated. The neural arches are complete and the neural canal measures 9.5 mm. in height posteriorly.

Seventh caudal.—The centrum (pl. 12, fig. 2) is shorter than that of the preceding caudal and the posterior facets for the chevrons are borne on longer and narrower descending processes; the anterior facets are more carinate, the transverse processes are shorter, the neural spine is considerably shorter and more noticeably constricted near the base. The anteroposterior diameter (15.5 mm.) of the left transverse process at the narrowest point is about one-fifth less than at the extremity (19.8 mm.); the distance from the canal at the base to the anteroexternal angle is 21 mm. The neural arches are complete, with a minimum anteroposterior diameter of 16.5 mm., and the height of the neural canal posteriorly is 8 mm. The minimum anteroposterior diameter of the neural spine near the base (16.7 mm.) is more than half the maximum diameter (28.4 mm.) at the extremity. The metapophyses are knoblike processes which project beyond the anterior epiphysis; they are carinate externally and their dorsal margins are at least 20 mm. above the top of the centrum.

Tenth caudal.—The neural spine (pl. 1, fig. 1) is broken above the level of the metapophyses and its extremity is missing. A large portion of this caudal is still hidden by the matrix. The height of the neural canal posteriorly is 6 mm. The enlargement on the posterior border of the neural spine about halfway between the extremity and the level of the metapophyses is the most unusual peculiarity. The minimum anteroposterior diameter of the neurapophysis is approximately the same as the minimum diameter of the neural spine. The inferior descending processes on which the posterior facets for the chevron are borne are thicker than those on the seventh caudal, but unlike those on the eleventh are not joined with the processes of the anterior facets by a continuous lamina of bone. The transverse processes are short, subtriangular in outline, and the distance from the foramen at the base to the anteroexternal angle is 16 mm.

Eleventh caudal.—The neural spine (pl. 13, fig. 1) is fractured at the base, but otherwise this caudal is practically complete. It is characterized by very short triangular transverse processes, a small neural canal, a short neural spine, and small metapophyses. The minimum anteroposterior diameter of the neurapophysis (19.5 mm.) is considerably greater than the minimum diameter of the neural spine (13.8 mm.). The height of the neural canal posteriorly is 4.5 mm. The paired descending processes on which are situated the posterior facets for the corresponding chevron are continuous anteriorly with those for the preceding chevron. The thin lamina of bone which connects these processes is perforated mesially by an elongate foramen. The distance from the foramen at the base of the transverse process to the anteroexternal angle is 13.5 mm. The lateral surface of the centrum is traversed obliquely by a broad groove which extends from the posterior margin of the neural arch to the above-mentioned foramen.

Twelfth caudal.—This caudal (pl. 13, fig. 2) is complete. The centrum is rather deep but is narrow transversely. The paired descending processes on which are situated the posterior facets for the corresponding chevron are swollen, occupying more than half the length of the centrum, continuous anteriorly with those for the preceding chevron, and are pierced mesially by a foramen of medium size. From this foramen a short broad groove extends upward to the inferior orifice of the lateral vertebrarterial canal. About 7.5

mm. in front of the posterior margin of the neural arch is a small foramen which leads from the neural canal and opens into a broad groove which extends downward across the lateral face of the centrum to the superior orifice of the lateral vertebrarterial canal at the base of the vestigial transverse process. The metapophyses project forward beyond the anterior epiphysis. The minimum anteroposterior diameter of the neural spine (13.7 mm.) is slightly more than one-half of the minimum diameter of the neural arch (21 mm.). The height of the neural canal posteriorly is 3.5 mm.

Thirteenth caudal.—It (pl. 13, fig. 3) is characterized by a very small neural spine, which is longer than high, small but distinct metapophyses, and a pair of thick platelike descending processes which extend the length of the inferior face of the centrum, with facets for chevrons at both ends. Each of these descending processes is pierced mesially by a small foramen which opens on the lateral face of the centrum into a short deep groove, that in turn leads to the lateral vertebrarterial canal. Above the dorsal orifice of this vertebrarterial canal is a short groove which, however, does not extend upward as far as the posterior margin of the neural arch. The distance between the dorsal and ventral orifices of the lateral vertebrarterial canal is 9 mm. The neural canal is very small. The centrum is pierced dorsoventrally near the middle by a pair of minute canals. The anterior epiphysis is missing.

Fourteenth caudal.—The posterior epiphysis (pl. 13, fig. 4) and the neural spine are missing, but otherwise the vertebra is complete. The centrum is as deep as long. Thick platelike descending processes bearing facets at the anterior and the posterior ends for chevrons extend the full length of the inferior surface of the centrum. They are separated mesially by the usual longitudinal excavation and are pierced behind the middle by a small foramen. The distance between the dorsal and ventral orifices of the vertebrarterial canal is 12.3 mm. This caudal apparently had a small neural spine, but it has been destroyed. The small neural canal is open, but the metapophyses are vestigial.

Terminal caudal.—This caudal measures 16.7 mm. in width, 6+mm. in thickness, and 9.5 mm. in depth. One face of the centrum was destroyed by the pick of the collector. The centrum is pierced dorsoventrally by a pair of large canals, the dorsal orifices of which are at least 5.8 mm. apart; the dorsal and ventral surfaces are convex from side to side. The side which appears to be the anterior face is convex. A pair of blunt processes are developed on each side at the dorsal and ventral angles by the mesial side to side constriction of the centrum, and in direction they are oblique to the transverse axis of the centrum.

Measurements of the caudal vertebrae (in millimeters)

	1st	2nd	3rd	6th	7th	10th	11th	12th	13th	14th
Greatest depth (vertically) of vertebra (tip of neural spine to inferior face of centrum)	x	x	x	68.4	75.3	[1]77+	56.6	49.3	42.2	31
Greatest height of centrum anteriorly	x	x	x	27	26.8	x	28.3	28.2	30.3	28
Breadth of anterior face of centrum	27.2	31.5	32.7	x	30	x	x	x	x	24.4
Greatest height of centrum posteriorly	29.5	32.3	x	32.4	32.5	31.8	32.8	32.7	30.5	28.2
Breadth of posterior face of centrum	30.2	31.5	31+	31.2	x	33.5	27.5	26	23.8	22.5
Length of centrum	39.5	[2]37.5	37.3	[2]33.8	33.8	29.5	29	28	27.8	[3]24.5
Distance from base of neural arch (inside margin) to tip of left transverse process	55	51	45	40	34	27.5	24	21	x	x
Maximum width of extremity of left transverse process	26.4	28.9	29.8	20.5	19.8	x	x	x	x	x
Minimum anteroposterior diameter of neurapophysis	16.7	x	16.9	16.7	16.5	17.7	19.5	21	19.5	15.5
Vertical height of neural spine (distance between superior margin of spinal canal and tip of spine)	x	x	x	44	36	42±	23.8	16.5	12	x

[1] Estimated. [2] Anterior epiphysis missing. [3] Posterior epiphysis missing.

CHEVRON BONES

Four chevron bones are preserved with the skeleton. One of them (pl. 13, fig. 5) belongs with an anterior caudal. It is the largest one of the four and has a wide blade, the anteroposterior diameter at the extremity being equivalent to about two-thirds of the depth of the chevron. Another chevron (pl. 10, fig. 6, and pl. 11, fig. 7) which belongs with some following caudal has a much broader blade, the anteroposterior diameter at the extremity being greater than the depth of the chevron. The inferior margin of the blade of this chevron is curved, while that of the preceding chevron is almost straight. The third chevron (pl. 11, fig. 6) belongs farther back and is smaller, but the anteroposterior diameter of the extremity of the blade is almost equivalent to the depth of the chevron; the inferior free margin of the blade is slightly curved. The smallest (pl. 11, fig. 8) of all these chevrons is probably the last in the series and may have belonged with the fourteenth caudal. The blade is very short and the anteroposterior diameter at the extremity is more than twice the depth of the chevron.

Measurements of the chevron bones (in millimeters)

	Chevron No. 1, pl. 13, fig. 5	Chevron No. 2, pl. 11, fig. 7	Chevron No. 3, pl. 11, fig. 6	Chevron No. 4, pl. 11, fig. 8
Depth of chevron	25.4	20.6	19	7.7
Antero-posterior diameter of blade at extremity	16.4	21	18.7	16.2
Antero-posterior diameter of articular facet on base of chevron (right side)	13	13.8	10.2	11
Distance between internal margins of articular facets on base of chevron	5	7.6	9.8	5

SCAPULA

The anterior half of the left scapula (pl. 1, fig. 1) is missing, but the posterior half is complete. The internal face is exposed and the external is hidden in the matrix. Aside from its smaller size, it resembles the corresponding portion of the scapula of *Delphinodon dividum*, but the posterior margin is not as deeply concave. The vertebral border is evenly convex. Scarcely any trace of ridges can be observed on the internal face of the blade, but there is a shallow depression in the mesial region which corresponds in a general way to the insertion of the subscapularis muscle. Between this depression and the posterior angle the internal surface of the scapula is flat; the serratus anticus muscle is inserted in this region in living porpoises.

Measurements of the left scapula (in millimeters)

Exterointernal diameter of head	16
Posterior margin of head to posterior angle of blade	78
Inferior margin of head of vertebral margin of blade	86

HUMERUS

With the exception of a portion of the epiphysis from the proximal end, all of the right humerus is missing. In size, this humerus is smaller than any of those hitherto obtained from the Calvert formation. The lesser tuberosity is considerably larger than the greater tuberosity, an anomalous condition which prevails in many of the living porpoises. On the outer half of the proximal face of the lesser tuberosity there is a well-defined ovoidal concavity which corresponds in position to the usual place for the attachment of the subdeltoid muscle. The bicipital groove is deep. The external face of the greater tuberosity is very rugose and in this area was attached a part of the deltoid muscle. Most of the head is missing.

Measurements of the right humerus (in millimeters)

Greatest exterointernal diameter of lesser tuberosity	18.5
Greatest anteroposterior diameter of lesser tuberosity	11.2
Greatest exterointernal diameter of epiphysis across lesser tuberosity	22.8

RIBS

Very few of the ribs are complete, and most of them are fractured in one or more places. The ribs were not disturbed when the slab in which they were embedded was prepared for exhibition and the whole or portions of 20 ribs are shown (pl. 14) in their original positions. Eight of those on the left side are associated with the corresponding dorsal vertebra. Those on the right side of the vertebral column lie in a more or less tangled pile.

Of the ten pairs of ribs the first were the shortest. Judging from those that are fairly complete, the ribs rapidly increase in length from the first (92–94 mm.) to the fifth (207+mm.) and then decrease in length to the tenth (147+mm.). The distal extremities of the first five pairs of ribs are expanded to provide for the attachment of cartilaginous sternal ribs. The capitula of the first to seventh ribs are borne upon long necks, the seventh rib having the longest neck and the first the thickest neck. On the first to fifth ribs, inclusive, the capitula are ovoidal in outline. The eighth, ninth, and tenth ribs are single headed. The first seven ribs have capitula which articulate with definite facets on the posterosuperior angle of the centra as well as tubercula which articulate with facets on the extremities of the diapophyses. On the eighth rib the articulation is with the diapophysis alone, and on the ninth and tenth with the parapophysis (transverse process).

The first rib (pl. 14, figs. 1, 10) is short, flattened, greatly expanded between the angle and the tuberculum; the capitulum is borne upon a short, thick neck. The tuberculum is larger than the capitulum. The shaft is nearly straight below the angle. The first rib is about three-fifths as long as the second, but the shaft of the latter (pl. 14, figs. 2, 11) is much less expanded between the angle and the tuberculum, and the neck is longer. The right rib of the third pair (pl. 14, figs. 3, 12) is more nearly complete than the left. This rib is characterized by a longer and more strongly curved shaft and the neck is thicker than the second rib. The expanded distal extremity is rather wide. Less than half of the right rib of the fourth pair (pl. 14, figs. 4, 13) is preserved and the one on the left side is broken in at least two places. The fourth and fifth ribs are very similar in most respects, but the latter (pl. 14, figs. 5, 14) is the longest. The necks of these two ribs are slender and curve upward to the extremity; the tubercula are ovoidal in outline and are broadest at the posterior end. A considerable portion of the sixth rib (pl. 14, figs. 6, 15) on the right side is missing and the one on the left side is for the most part concealed by matrix. The shaft of the sixth rib is more slender than any of the preceding, the capitulum is smaller and more nearly circular, and the tuberculum is pyriform in outline. The shaft of the seventh rib (pl. 14, figs. 7, 16) is much narrower than any of the preceding, resembling the eighth in this respect; the extremity is thin, but there is a distinct surface for the attachment of a cartilaginous sternal rib. The eighth, ninth, and tenth ribs have a single facet at the proximal end and slender shafts which are slightly bowed. All of these posterior ribs are rather thin at the distal end, with one face flattened and the other more or less convex. The eighth rib (pl. 14, fig. 8) has a more elongate capitulum than either of the following ribs.

Measurements of the ribs (in millimeters)

	First rib		Second rib		Third rib		Fourth rib		Fifth rib	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Greatest length in a straight line	93. 9	92	150	152	145+	126+	197±	93+	207±	121+
Greatest breadth of shaft at angle	18. 5	17. 8	9. 6	10	9. 2	x	9	x	8. 2	7. 9
Distance between external margin of tuberculum and anterior margin of capitulum	25. 8	25. 8	22. 5	x	x	x	22. 7	x	22. 2	x
Greatest thickness of shaft near the middle	3. 8	x	3. 9	4	x	4. 6	x	4	4	4. 7
Greatest diameter of articular facet on head of rib	6. 1	6. 5	6. 5	x	6. 9	6. 7	7. 8	x	5. 5	x
Greatest diameter of articular facet on tubercle of rib	10. 1	10	x	9. 5	x	x	11	x	10. 2	x
Least breadth of neck	7	6. 7+	6. 9	x	6. 8	5. 2	7. 5	x	5. 9	x

Measurements of the ribs (in millimeters)—Continued

	Sixth rib		Seventh rib		Eighth rib		Ninth rib		Tenth rib	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Greatest length in a straight line	x	x	201+	x	192+	x	183. 5	x	147+	x
Greatest breadth of shaft at angle	7. 5	7. 2	6. 5	x	6	x	x	x	x	x
Distance between external margin of tuberculum and anterior margin of capitulum	20. 5	x	26	26. 5	x	x	x	x	x	x
Greatest thickness of shaft near the middle	x	x	x	5	4. 4	x	4	x	3. 8	x
Greatest diameter of articular facet on head of rib	5. 8	x	5. 8	x	10. 7	x	7. 8	x	x	x
Greatest diameter of articular facet on tubercle of rib	8. 5	x	11. 8	12	x	x	x	x	x	x
Least breadth of neck	4. 8	x	4. 9	x	x	x	x	x	x	x

EXPLANATION OF PLATES

Kentriodon pernix. Cat. No. 8060, Division of Vertebrate Palaeontology, United States National Museum. Calvert formation, western shore of Chesapeake Bay, about one and one-half miles south of Chesapeake Beach, Calvert County, Maryland. Collected by Norman H. Boss, July 5–7, 1913. Cat. No. 10670, Division of Vertebrate Palaeontology, United States National Museum. Calvert formation, western shore of Chesapeake Bay, south of Chesapeake Beach, Calvert County, Maryland. Collected by William Palmer, July, 1918.

The following abbreviations are used on plates 3 to 7. *Al.*, alisphenoid; *Ant. n.*, antorbital notch; *Ap. max.*, apophysis of maxilla; *Bo.*, basioccipital; *Bs.*, basisphenoid; *C.*, condyle; *Cr. l.*, lambdoid crest; *Ex. oc.*, exoccipital; *Fal. pr.*, falcate process of basioccipital; *Fo. h.*, hypoglossal foramen; *Fo. inf.*, infraorbital foramen; *Fo. m.*, foramen magnum; *Fo. max.*, maxillary foramen; *Fo. pmx.*, premaxillary foramen; *Fr.*, frontal; *J. inc.*, jugular incisure; *Ju.*, jugal; *La.*, lachrymal; *Max.*, maxilla; *Na.*, nasal; *N. A.*, respiratory passage; *Pa.*, parietal; *Pmx.*, premaxilla; *Poc. pr.*, paroccipital process of exoccipital; *Pt.*, pterygoid; *S. oc.*, supraoccipital; *S. or. pr.*, supraorbital process of frontal; *Sq.*, squamosal; *Vo.*, vomer; *Zyg.*, zygomatic process of squamosal; *1*, passage for mandibular branch of trigeminal nerve in a cleft on posterior border of alisphenoid; *2*, foramen lacerum posterius.

PLATE 1

Fig. 1, Skeleton of *Kentriodon pernix.* Matrix has been removed to show the position of the various elements. Cat. No. 8060, U.S.N.M. About one-seventh natural size. Left tympanic bulla, about natural size. Fig. 2, Ventral view; Fig. 3, External view; Fig. 4, Internal view; Fig. 5, Dorsal view.

Plate 2

Dorsal view of skull of *Kentriodon pernix*. Cat. No. 8060, U.S.N.M. About three-fifths natural size. Allowance must be made for distortion, because this is a photograph of the image of the dorsal surface in the mirror back of the skull on the skeleton now on exhibition.

Plate 3

Fig. 1, Posterior view of skull of *Kentriodon pernix*. Cat. No. 10670, U.S.N.M. About eight-elevenths natural size. Left periotic, about seven-thirds natural size. Fig. 2, Tympanic or ventral view; Fig. 3, External view; Fig. 4, Cerebral or internal view.

Plate 4

Ventral view of skull and cervical vertebrae of *Kentriodon pernix*. Cat. No. 8060, U.S.N.M. About one-half natural size.

Plate 5

Lateral views of skulls of *Kentriodon pernix*. About eleven-twentieths natural size. Fig. 1, Skull, Cat. No. 8060, U.S.N.M.; Fig. 2, Skull, Cat. No. 10670, U.S.N.M.

Plate 6

Dorsal view of skull of *Kentriodon pernix*. Cat. No. 10670, U.S.N.M. About eleven-twentieths natural size.

Plate 7

Ventral view of skull of *Kentriodon pernix*. Cat. No. 10670, U.S.N.M. About eleven-twentieths natural size.

Plate 8

Views of seven teeth of *Kentriodon pernix*. Cat. No. 8060, U.S.N.M. About three times natural size. Fig. 1, Anteriormost tooth in mandible; Fig. 2, Tooth from anterior end of middle portion of tooth row; Fig. 3, Tooth from posterior end of middle portion of tooth row; Figs. 4–7, Teeth from near anterior end of tooth row.

Plate 9

Lateral views of posterior dorsals and anterior lumbars of *Kentriodon pernix*. Cat. No. 8060, U.S.N.M. About natural size. Fig. 1, Eighth dorsal, partially concealed by shafts of fifth and eighth ribs; Fig. 2, Ninth dorsal, partially concealed by shafts of fifth, eighth, and ninth ribs, and with extremity of neural spine restored; Fig. 3, Tenth dorsal, partially concealed by extremity of ninth rib, and with right transverse process and extremity of neural spine restored; Fig. 4, First lumbar, with extremity of neural spine and right transverse process restored; Fig. 5, Second lumbar, with extremity of neural spine and right transverse process restored; Fig. 6, Third lumbar, with centrum, right neurapophysis, and right transverse process restored.

PLATE 10

Lateral views of posterior lumbar, anterior caudals, and chevron of *Kentriodon pernix*. Cat. No. 8060, U.S.N.M. About natural size. Fig. 1, Last lumbar, with right transverse process, neural arches, and neural spine restored; Fig. 2, First caudal, with extremity of neural spine restored; Fig. 3, Second caudal, with neural arches and neural spine restored; Fig. 4, Third caudal, no restoration; Fig. 5, Anterior epiphysis of Fourth caudal; Fig. 6, Chevron of an anterior caudal.

PLATE 11

Dorsal views of posterior lumbars and anterior caudals of *Kentriodon pernix*. Cat. No. 8060, U.S.N.M. About three-fourths natural size. Fig. 1, Left transverse process of next to last lumbar, with anteroexternal angle restored; Fig. 2, Last lumbar, with right transverse process, neural arches, neural spine, and anteroexternal angle of left transverse process, restored; Fig. 3, First caudal, with extremity of neural spine restored; Fig. 4, Second caudal, with extremity of right transverse process, neural arches, and neural spine restored; Fig. 5, Third caudal, no restoration; Fig. 6, Lateral view of chevron of an anterior caudal; Fig. 7, Dorsal view of chevron of an anterior caudal; Fig. 8, Dorsal view of chevron of a posterior caudal; Fig. 9, Anterior epiphysis of fourth caudal.

PLATE 12

Lateral views of caudal vertebrae of *Kentriodon pernix*. Cat. No. 8060, U.S.N.M. About natural size. No restoration. Fig. 1, Sixth caudal; Fig. 2, Seventh caudal. Atlas of *Kentriodon pernix*. Cat. No. 11400, U.S.N.M. About nine-elevenths natural size. Fig. 3, Anterior view of atlas; Fig. 4, Posterior view of atlas.

PLATE 13

Lateral views of caudal vertebrae and an anterior chevron of *Kentriodon pernix*. Cat. No. 8060, U.S.N.M. About natural size. No restoration. Fig. 1, Eleventh caudal; Fig. 2, Twelfth caudal; Fig. 3, Thirteenth caudal; Fig. 4, Fourteenth caudal; Fig. 5, Chevron of an anterior caudal.

PLATE 14

Ventral view of vertebral column of *Kentriodon pernix* with associated ribs. Cat. No. 8060, U.S.N.M. About one-half natural size. No restoration. 1, First rib, left; 2, Second rib, left; 3, Third rib, left; 4, Fourth rib, left; 5, Fifth rib, left; 6, Sixth rib, left; 7, Seventh rib, left; 8, Eighth rib, left; 9, Ninth rib, left; 10, First rib, right; 11, Second rib, right; 12, Third rib, right; 13, Fourth rib, right; 14, Fifth rib, right; 15, Sixth rib, right; 16, Seventh rib, right; 17, Eighth rib, right; 18, Atlas; 19, Axis; 20, Left parapophysis, third cervical; 21, Fourth cervical; 22, Fifth cervical; 23, Sixth cervical; 24, Seventh cervical; 25, First dorsal; 26, Second dorsal; 27, Third dorsal; 28, Fourth dorsal; 29, Fifth dorsal; 30, Sixth dorsal; 31, Seventh dorsal; 32, Eighth dorsal; 33, Tenth caudal; 34, Eleventh caudal; 35, Twelfth caudal; 36, Thirteenth caudal; 37, Fourteenth caudal; 38, Chevron of an anterior caudal.

O